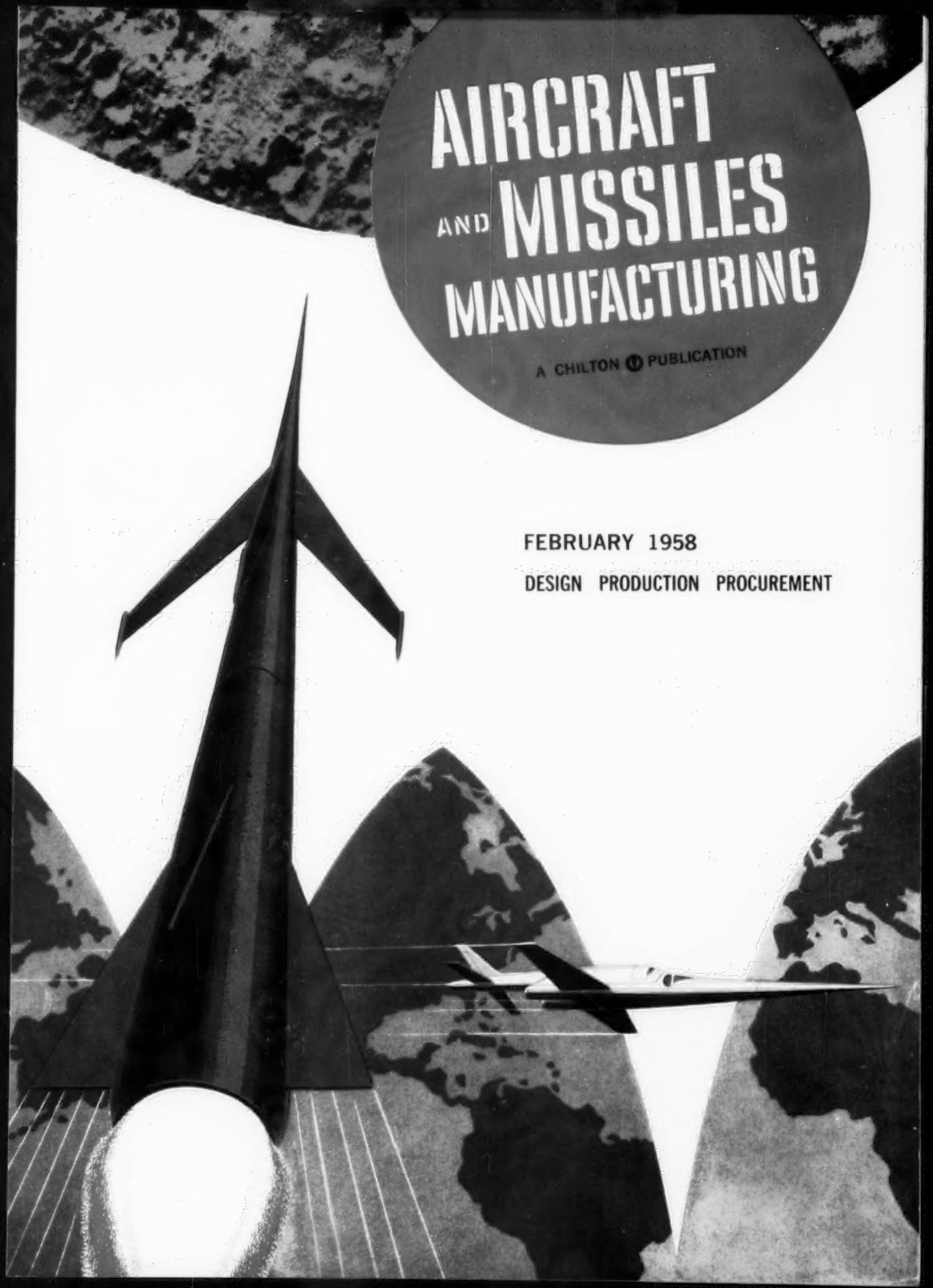
AIRCRAFT AND MISSILES MANUFACTURING

A CHILTON PUBLICATION



FEBRUARY 1958

DESIGN PRODUCTION PROCUREMENT

FOR SPRING STEEL FASTENERS

QUALITY BEGINS WITH SHARONSTEEL

The manufacture of fasteners requires steel of the most exacting analysis. Spring quality steels of just the right degree of hardness to permit volume manufacture of hundreds of complicated and complex shapes.

Leading fastener manufacturers look to Sharon as a first source of supply because they have learned they can rely on Sharon to deliver finest quality to precise specifications — coil after coil.

SHARON STEEL CORPORATION

SHARON, PENNSYLVANIA

Circle 82 on Inquiry Card, page 65

SCIAKY

HELPS PUT PROFIT
INTO MANUFACTURING

Heintz Achieves Volume Production with New Sciaky Counter Control Welders

In fabricating and job shops, where a wide variety of assemblies must be welded to rigid specifications every day, Sciaky resistance welding helps keep production schedules *on schedule*.

The Jet Engine Division of the Heintz Division, Kelsey-Hayes Company, a large Philadelphia contract fabricator, manufactures original and replacement parts for the aircraft industry. This means their production must meet exacting jet engine specifications.

New Sciaky Counter Control

To help meet these requirements, Heintz now uses Sciaky Patented Three-Phase Resistance Welders with the new Predetermined Electronic Counter Control. This new unit provides precise control of all welder functions for absolute production consistency. All control settings are realized with extreme accuracy, and are readily reproduced at any time to duplicate previous production runs. The machine cannot deviate from its setting.

Fig. 1 Seam welding Nimonic to Nimonic on Pratt & Whitney Aircraft J-57 afterburner diffuser section.

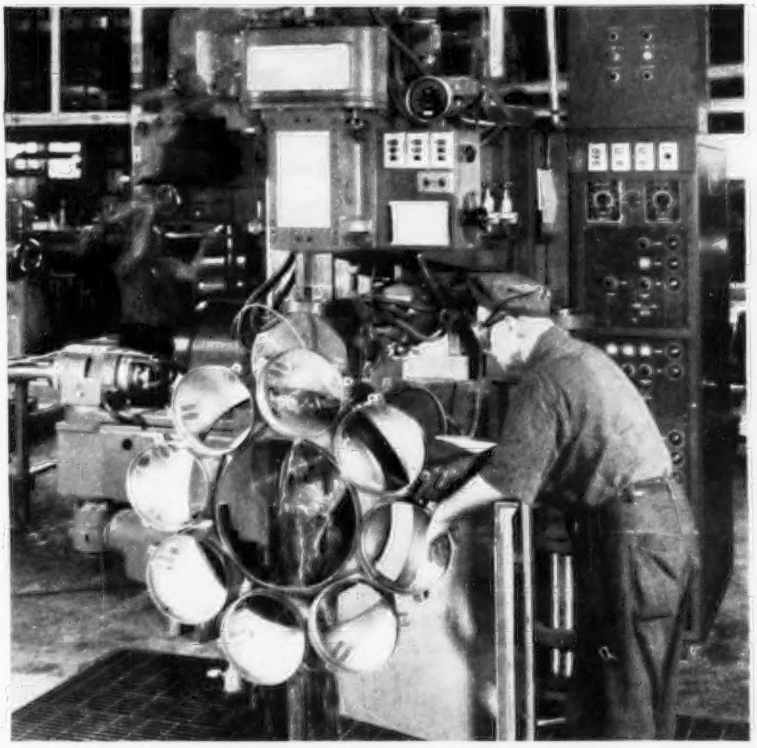


Fig. 2 Seam welding stainless to stainless on Pratt & Whitney Aircraft J-57 jet engine transition duct assembly. Note simple fixture used.

The Sciaky Predetermined Electronic Counter Weld Control is the only control of this type that has been proved in service, and the first unit of this kind has now been in use nearly two years.

How It Works

The Sciaky Predetermined Electronic Counter Control counts the cycles of power line frequency which is governed by the U.S. Naval Observatory. In predetermined absolute numbers, cycles and impulses are simply counted by a Dekatron tube to control the duration of the various welder functions. The absolute consistency of the control eliminates the need for time-consuming periodical check-out or calibration. Plug-in feature permits easy unit replacement, or addition of other control functions if required.

Operations Performed

Photos show typical Sciaky resistance welding applications on jet engine parts—Afterburners, Screech Screens, Engine Duct Assemblies, etc. Materials welded include Nickel Alloy, Nimonic and Stainless Steel.

Information Available

Case histories outlining the successful use of Sciaky Resistance Welding Techniques on jet engine components are available on request. Specific recommendations will be furnished on receipt of an outline of your requirements.

Write today, mentioning the information you would like to receive. There is no obligation. Sciaky Bros., Inc., 4941 W. 67th St., Chicago 38, Ill. POrtsmouth 7-5600. 62 C

contents

FEBRUARY 1958

VOLUME 1, NUMBER 2

DESIGN
PRODUCTION
PROCUREMENT

A CHILTON PUBLICATION

THE COVER STORY

Spectacular developments in rocketry have recently captured man's insatiable imagination. He is soon to embark upon conquering the last frontier of his physical environment. There will be, however, an extended period of transition stretching through the second half of this century during which the airplane, though now less spectacular, will continue to perform many prosaic but still essential functions in the immediate vicinity of this shrinking planet.

FEATURES

PAGE	
10	aluminum sculpture milling
14	SeaMaster
20	phenolic impregnated silica fabric
23	ICBM tooling
24	manufacturing the light plane
29	history of producibility at Boeing
31	plastic tooling—epoxies move in
36	plastic fuselage
40	spin forming
48	arc-welding titanium
54	nital etch inspection

DEPARTMENTS

PAGE	
7	editorial orbit
59	producibility review
61	new for production
69	materials and components
73	worth asking for
75	men on the move
84	your date book
84	index to advertisers

INDUSTRY NOTES

77	test chamber simulates 100,000 ft and 830° F
78	slow vans, swift missiles are paradoxical partners
78	lawmaker asks formula for defense profits
79	reinforced plastics seen as space-flight material
80	industry statistics
81	six step space program of American Rocket Society submitted to President
83	Navy orders Mach 2 inertially guided Regulus
83	man can soon fly aircraft in space
84	no rivalry here

FOR THREADED INSERT DRIVING
and
Stud Setting and Pulling

Automatic Self-Opening Stud Driver — 100 Series Featuring Collapsible Type Trip Gage!

Automatic take-up for wear on jaws. Affords accurate maintenance of projection heights. Inexpensive method of clutch renewal gives double wear at half the cost.

"Presto" Magic Type QUICK CHANGE CHUCKS

For both VERTICAL and HORIZONTAL applications. Just lift ring to insert or remove collets — without slowing spindle. R. P. M. Famous TITAN concealed tension spring. No external snap rings to snag hands.

"Bull Dog" Stud Driver Designed for Use With Impact Wrenches

Built for rugged use on heavy engines. Equipped with Titan Design, Loose Pressure Plunger. Definitely stands up under vibration encountered when using an impact wrench for motive power.

Titan "Roll Grip" Combination Stud Driver and Puller

Incorporates roll action to grip as little as .25 mm. of stud threaded body of stud. Made in standard sizes from 5/16 to 1 in. inclusive.

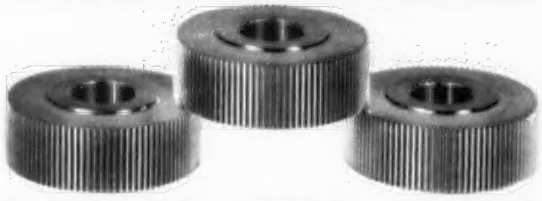
TITAN TOOLS — World's Largest Producers Of Stud Drivers And Pullers

TITAN TOOL CO.

48 MAIN ST., FAIRVIEW (ERIE COUNTY), PA.

Circle 86 on Inquiry Card, page 65

Ultra High Precision Fine Pitch



MASTER SPUR GEARS

immediate delivery from stock

.0002 Maximum Composite Error
20 Pitch and Finer
14-1/2° and 20° Pressure Angles
Hardened and Ground Tool Steel
Quick Delivery on Non-stock Items

INVO SPLINE, INC.

2363 E. NINE MILE ROAD • HAZEL PARK, MICHIGAN
PHONE: SLOCUM 7-8840

Circle 87 on Inquiry Card, page 65

staff | AIRCRAFT AND MISSILES MANUFACTURING

EDITORIAL

W. THOMAS H. MacNEW, Editor
S. PETER KAPRIELYAN, Technical Editor
JOHN P. KUSHNERICK, Materials Editor
ROBERT McFARLAND, Production Editor
MARCUS AINSWORTH, Statistical Editor
HAROLD NELSON, Specifications Editor
D. DAVIS, Art Editor
HOWARD KOHLBRENNER, Art Director

REGIONAL and FOREIGN EDITORS

West Coast—ROBERT McLARREN, Executive Editor
Cleveland— JOHN KEVERN, Technical
Detroit— JOSEPH GESCHELIN, Technical
HUGH C. QUINN, News
Washington—GEORGE H. BAKER, Chief
RAY M. STROUPE, News
NEIL R. REGEIMBAL, News
Washington Member, Editorial Board—PAUL WOOTON
Europe— RONALD A. COLE

BUSINESS

JOHN C. HILDRETH, JR., Publisher
JOHN F. PFEFFER, Asst. to Publisher
E. H. MILLER, Advertising Manager
JAMES CADAGAN, Circulation Manager

REGIONAL SALES MANAGERS

Chicago—RICHARD P. McCLANAHAN
360 N. Michigan Ave. RAndolph 6-2166

Cleveland—GEORGE KILBRIDE
930 B. F. Keith Bldg. SUperior 1-2860

Dallas—WILLIAM J. SMYTH
909 Mercantile Securities Bldg. RIverside 7-1732

Los Angeles—JACK KAY
198 S. Alvarado St. DUnkirk 7-4337

New York—TED DRISCOLL
100 E. 42nd St. OXford 7-3400

Philadelphia—GEORGE ISHERWOOD
Chestnut & 56th Sts. SHerwood 8-2000

San Francisco—DON MAY
1355 Market St. UNderhill 1-9737

Tulsa—JOHN W. SANGSTON
621 Petroleum Bldg. LUther 4-1769

CHILTON COMPANY, OFFICERS AND DIRECTORS:

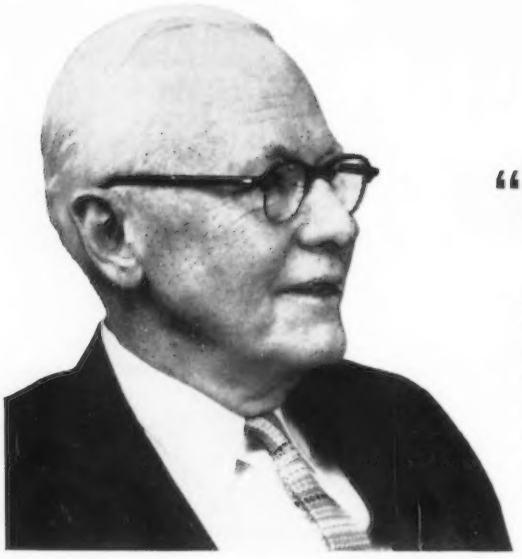
Chairman of the Board: JOSEPH S. HILDRETH
President: G. C. BUZBY
Vice Presidents
P. M. FAHRENDORF — HARRY V. DUFFY
LEONARD V. ROWLANDS — GEORGE T. HOOK
ROBERT E. McKENNA
Treasurer: WILLIAM H. VALLAR
Secretary: JOHN BLAIR MOFFETT
MAURICE E. COX — FRANK P. TIGHE
EVERIT B. TERHUNE, JR. — RUSSELL W. CASE, JR.
JOHN C. HILDRETH, JR.
Comptroller: STANLEY APPLEBY

Editorial and Executive Offices: Chestnut and 56th Sts., Philadelphia 39, Pa. SHerwood 8-2000

Accepted as controlled circulation publication at Philadelphia, Pa.

Copyright 1958 by Chilton Company.

Published monthly. Subscription rates: United States, $5.00 per year. Canada and Foreign Countries, $10.00 per year. Single copies 50c each.



"industrial publications have

For all of the 37 years since he left Officers' Training Camp at the close of World War I, Reed Schreiner has been in steel. Seven years ago he became Director of Advertising for the United States Steel Corporation, a position for which he qualified by serving the Corporation and its various subsidiaries in many capacities from copywriter to Assistant Director of Advertising. We recently visited Mr. Schreiner in his Pittsburgh office to learn something about his philosophy and experience in the use of business publications. Here are the highlights of our long and pleasant talk with this seasoned advertiser.

Q Tell me, Mr. Schreiner, just how many years has your corporation been advertising?

A I'm afraid that's a question that cannot be answered without considerable research. This corporation is the sum total of many different organizations whose advertising histories are obscured by time. I think I can best answer your question by saying that we've been at it for a long, long time.

Q I'm certain that the record reveals many interesting highlights and advertising firsts. Among them, what do you consider to be of particular interest?

A Well, one advertising first that immediately occurs to me is the fact that we were among the very first, possibly the first, to use the cartoon technique in industrial advertising.

Q And that was how long ago?

A Offhand, I'd say about 1930.

Q And how about a highlight from your postwar advertising activities?

A Well, as you perhaps already know, we were the first basic material producer to promote the products of our customers in the consumer market on an industry-wide basis. By that I mean we promote the use of steel, not just U.S. Steel, with the firm belief that we will get our fair share of the steel business created.

Q That is very interesting. Tell me, did you use business publications for this undertaking?

A Yes, we did and still do. And very extensively, I might add.

Q Just what is your philosophy in respect to business publications, Mr. Schreiner?

A We regard them as a vital link in our chain of communications. Properly used, they contribute importantly toward the attainment of our sales objectives. We know of no better way to reach industrial buying influences economically and efficiently.

Q Approximately how many business publications do you use?

A Something more than 300.

Q What percentage of your space budget goes into business publication advertising?

A About 28%. And you will be interested to know that this represents the largest single expenditure in our advertising budget.

Q For what specific purposes do you use business publications?

A I would say that we have two basic reasons. The first, of course, is to reach the many and varied buying influences in which we have an interest. The second is to conserve the time of our salesmen.

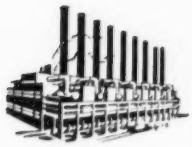
Q With a product and organization such as you have, your salesmen certainly do not have to overcome the more common obstacles, Mr. Schreiner. Just how, then, does business publication advertising help conserve their time?

A In many ways, but I'll illustrate just

one. Not very long ago we developed and introduced a new constructional alloy steel, and we advertised this fact in appropriate business publications. Our salesmen reported that as a result, they generally found the customer familiar with the new product and eager to discuss it. In a word, the advertising had done the spadework for the salesman—had saved him the time it would have taken to introduce this product to an unconditioned prospect.

Q What, in general, do your salespeople have to say about your use of business publications?

A I think their opinion about the value of business publications is best evidenced by the fact that they are constantly after us here in Advertising to do more and more—to add publications, to increase our use of those we are already in.



leadership responsibility to their industries"

Q What do you think the average reader looks for principally in a business publication?

A For information pertinent to his particular industry, for trade news, for a report on new developments and new products which may directly or indirectly affect him. But more importantly, I think he looks for an accurate, impartial interpretation and analysis of the news and developments within the

industry. It is for this reason that I say business publications have leadership responsibility to their respective industries. Not only do they help the reader do a better job today, but very often they have a definite influence on his personal development and growth within an industry.

Q What general rule or rules do you apply to the preparation of advertisements in business publications?

A We firmly believe in factual information advertising that features the merits of our products without reference to competitive products.

Q Do you feel that advertisements are important to the reader of a business publication?

A Indeed I do. Not so long ago, we asked a group of some 250 busy officials in various industries whether or not they would prefer the business publications they regularly read to carry no advertising. While I am not at all surprised at the outcome, I am surprised by the one-sidedness of the attitude revealed—96% said the elimination of advertising would be highly undesirable.

Q Do you feel that business publications are increasing in importance?

A Definitely. New developments are coming along so fast, and business is becoming so complex, that the need for the many services rendered by business publications is greater than ever before.

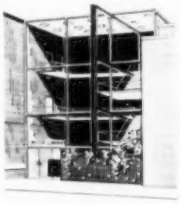
Q What are your criteria for the selection of a business publication?

A In general terms we look for the publications having acceptance within an industry. We naturally consider such important factors as editorial content, circulation, and selling power, but if you find evidence of high reader acceptance you can be certain that all the other considerations are in line.

★ ★ ★

Modern business publications are the all-important link between you and the buying influences you want to reach. They provide the means for reaching your prospects and customers on common ground—at a time when they are receptive to your sales message. In this respect, business publications fill a role unduplicated by any other known selling force.

Chilton publications cover their fields with an editorial excellence and a quality of circulation that assure confidence on the part of readers and advertisers. With such acceptance goes a proportionate selling power. Let Chilton publications help give your advertising maximum effectiveness.



Chilton
COMPANY

Chestnut and 56th Streets • Philadelphia 39, Pennsylvania

CHILTON PUBLICATIONS: The Iron Age • Department Store Economist • Spectator Hardware Age • Hardware World • Jewelers' Circular-Keystone • Motor Age Automotive Industries • Distribution Age • Optical Journal and Review of Optometry Boot and Shoe Recorder • Commercial Car Journal • Butane-Propane News Gas • Electronic Industries • Aircraft & Missiles Manufacturing • Book Division

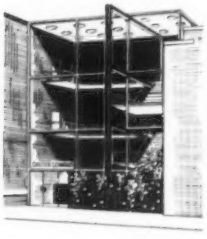
G-2

Time and again the military victory goes to the commander who is best informed—the general who knows the most about his enemy, about his flanking and supporting troops, about the terrain that lies ahead, and all the other bits of information that come from G-2, his intelligence staff.

Almost without exception, the profits and success in business go to the men who know the most about their competition, about their markets, about trends in their industry, and all the other information reported to them, faithfully and accurately, in the pages of their trade or industrial press.

* * *

Constant concern for editorial excellence is one of the main reasons for the sustained reader interest in the 16 trade and industrial magazines published by Chilton. Readers know they will find what they want and need . . . what they read will be timely and authentic. The result is an audience receptive to the products and services advertised in Chilton publications.



Chilton
COMPANY

Chestnut and 56th Streets • Philadelphia 39, Pennsylvania

CHILTON PUBLICATIONS: Department Store Economist • The Iron Age • Hardware Age • Spectator • Hardware World • Jewelers' Circular-Keystone • Automotive Industries • Gas • Distribution Age • Optical Journal and Review of Optometry • Motor Age • Boot and Shoe Recorder • Commercial Car Journal • Butane-Propane News • Electronic Industries • Aircraft & Missiles Manufacturing • Book Division

paradox of technological manpower

A lot of people are clamoring for more scientists and engineers. At this time, it seems we want to add more men to the bench when all of the first team can not get into the ball game.

Now, if we do need so many more engineers, why then has the industry released them in such large numbers in recent months? The answer, of course, is simple—lack of company funds because of contract cancellations.

If the industry continues to have major contractual fluctuations throughout individual companies, the engineering manpower situation will not improve.

If we simply attempt to augment the number of engineers and scientists without revising the present system of contract award and cancellation, we will be sowing the seeds of bigger layoffs and more serious economic setbacks for the future. Concurrently with the effort being spent to swell the engineering and scientific ranks, 10 years hence, we must also review and revamp our present method of awarding government contracts to prevent demoralizing fluctuations.

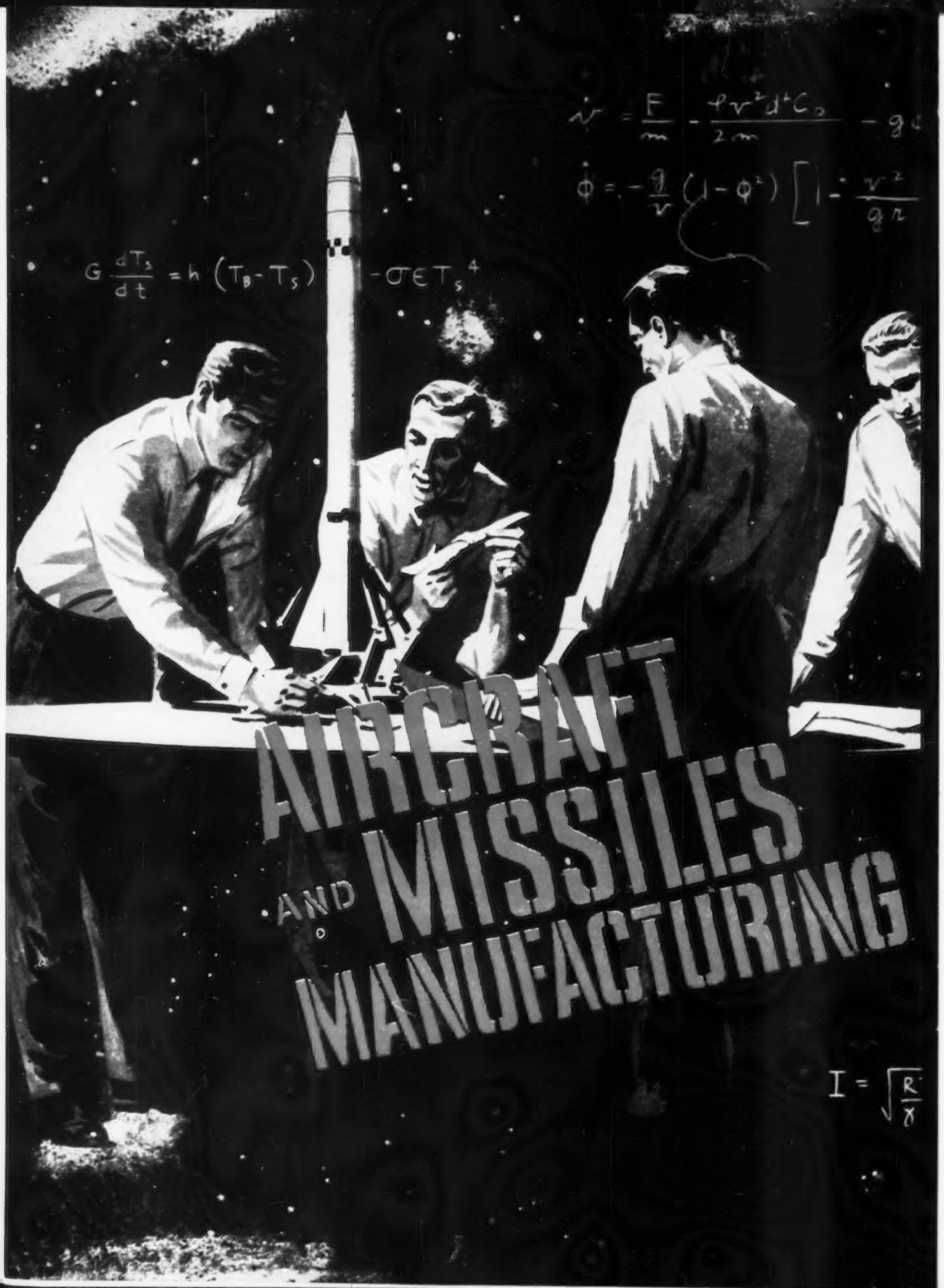
The present situation is not only a difficult one for the engineering work force, but also for management. Just when a company has its engineering department fully staffed and working at top efficiency, a government contract is cut and layoffs begin.

This situation of a company constantly building up and then tearing down its engineering structure certainly does not improve product lines. When a new contract is obtained, many of the experienced people are gone and the firm has to practically start engineering all over again.

How about personnel suffering the layoffs in the aircraft and missile industry? Sure, there are jobs in other geographical areas and even in other fields. Why should these people be scientific gypsies, however? Think of the effect this has on the coming generation of scientists and engineers. If we need these people so badly, let's sell them on this profession by providing them with some measure of professional stability.

If we are apparently capable of taking a giant step into the universe, we certainly can not afford to neglect this associated problem at the home base, which may be less spectacular but probably no less vital for the long run.

Editor


$\dot{v} = \frac{F}{m} - \frac{\rho v^2 d^2 C_D}{2m} - g$
$\dot{\phi} = -\frac{g}{v}(1-\phi^2)\left[1 - \frac{v^2}{gr}\right.$
$G\frac{dT_s}{dt} = h(T_B - T_s) - \sigma\epsilon T_s^4$
AIRCRAFT AND MISSILES MANUFACTURING
$I = \sqrt{\frac{R}{\gamma}}$

OUTER SPACE...the known and unknown!

Today's drawing boards mirror tomorrow's advances in outer space. The key to our future progress . . . the ability of our engineers and scientists to develop, design and produce a comprehensive practical program is up to you!

Educate this integrated team... Tell the engineers concerned with "design for producibility" . . . the men on the practical level of designing airframes, components, power plants, systems and controls. Capture the key production and engineering executives responsible for tooling, welding, forming, finishing, quality control, testing, materials handling, assembly and component installation. Transmit vital information on your product to the men who buy and specify in this $10-billion industry. Do your telling *now* via the advertising pages of their publication AIRCRAFT AND MISSILES MANUFACTURING. *They are interested in you, your products and services.*

AMM offers practical editorial diet... No other publication does such a specific editorial job. AMM is the *only* publication that concentrates editorial on the needs of the men in design, production and procurement. Here are a few typical editorial features found in AMM . . . Nital Etching Gears (production and inspection) . . . Bomarc Pressurized Fuel (design and production) . . . Electra Turboprop Transport (design and production) . . . plus important Industry Notes . . . Producibility Review and New Materials and Equipment.

Concentrate your advertising in AMM... Now a publication hand tailored to the audience. Edited for the men you want to sell. Circulated *only* to the men who specify and buy. In the advertising pages of AMM you can now economically reach this market of over 16,000 men actually responsible for building a future in outer space.

Art courtesy of Jet Propulsion Laboratory. JPL a division of California Institute of Technology provides a wide range of research and development activities.

AIRCRAFT AND MISSILES MANUFACTURING

A Chilton Publication, 56 & Chestnut Streets, Philadelphia 39, Pa. Tel: SHerwood 8-2000

aluminum sculpture-milling achieves industry status

by Robert McLarren, Executive Editor

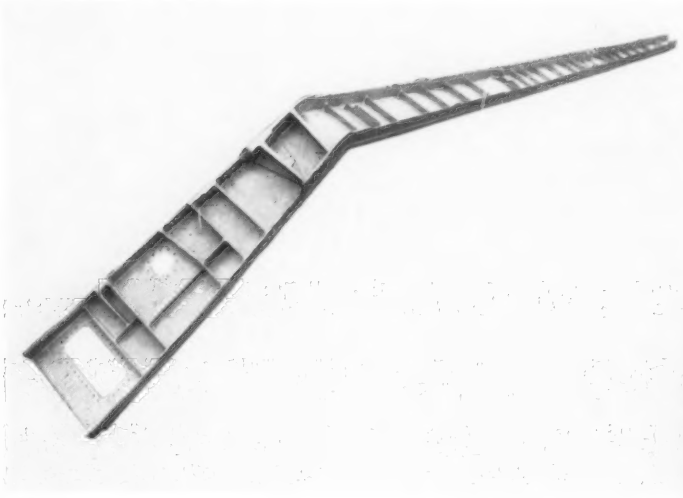
Sculpture-milling of aluminum has become a separate, thriving member of the aircraft industry in the past four years. Independent, specialist firms now account for an estimated 50 per cent of the sculpture-milling performed in aircraft production, and its application is growing rapidly with each succeeding aircraft design.

Aluminum sculpture-milling has become a major, vital operation in airframe manufacture through the production of integrally-stiffened parts. This design eliminates thousands of fasteners previously employed in a single wing skin while increasing its strength and decreasing its weight. For example, the use of integrally-stiffened skin panels in a transport aircraft wing replaced 1500 separately designed parts, such as doublers, stiffeners and clips, and eliminated an estimated 5000 rivets.

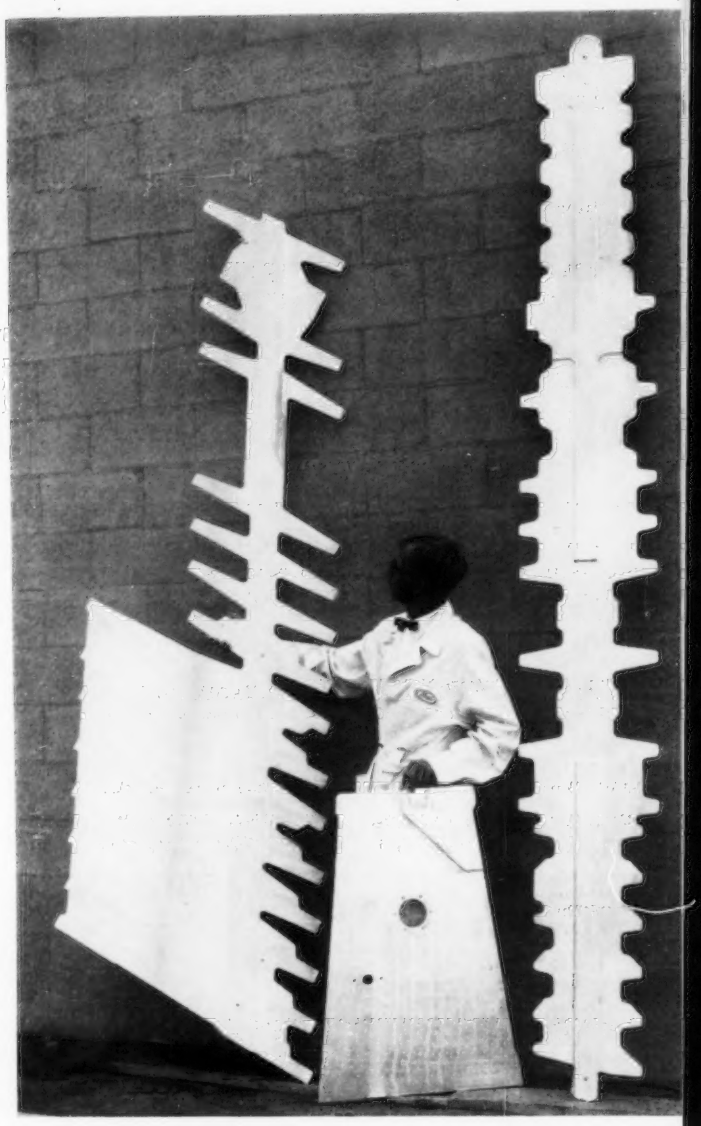
Integrally-stiffened parts can also be made by forging, casting, rolling, and extruding; but these processes require very high tooling expenditure justified only by high production runs, and still require finish machining. Integrally-stiffened panels are also being machined from forged and extruded panels, but the necessary dies for both operations require long lead-time planning.

The full benefits of integral-stiffening are realized only in very large skin panels, since joints requiring fasteners defeat the purpose of the method. Therefore, skin-milling equipment requires extremely long, wide beds. The relation between local loading and skin thickness-stiffening for weight-saving results in extremely complex panels with numerous pads, smooth corner contours, stiffener rises and drops, and short local stiffeners. These design complexities require

From an 1800-lb forged aluminum billet a 72-lb component is produced by deep pocket machining. Angle tolerance of finished part is ±15 sec.



specialists in skin tapering, spar milling, and machine sculpturing now vital members of airframe production team



Examples of close tolerance, sculptured components used in current commercial aircraft.

associated cams for guidance of the milling heads as the work moves past the cutter. Most airframe companies have solved these problems through the use of coded tape or card controlled systems.

These automatically-controlled machines are economically justified when:

- Aircraft performance is primary (combat types)
- Production quantities are large
- Programming lead-time is permissible
- Production schedules are not critical
- Equipment is not otherwise available

The Department of Defense has sponsored the development and installation of large milling equipment in most major airframe plants. These installations are tape-controlled, and despite individual modifications to equipment, tapes are carefully designed for interchangeability between plants, to permit mobilization of critical item production when required. However, the enormous operating cost, tooling and floorspace needed to utilize such machines have created the opportunity for independent sculpture-milling firms to undertake complete jobs on a price and delivery bid attractive to the airframe manufacturers.

Automobile Tooling Practices Adopted

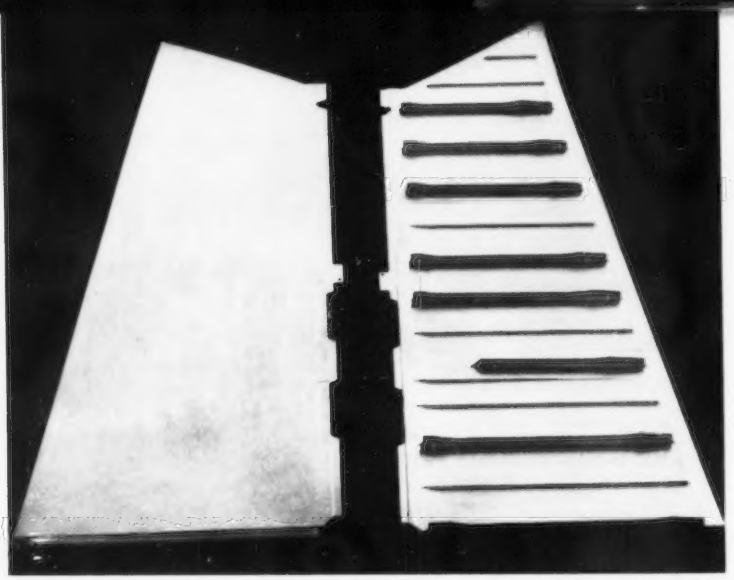
Leading independent supplier of sculpture-milled aircraft parts is Aluminum Taper Milling, a division of Altamil Corp. of El Segunda, Calif., which is currently installing new equipment that will make it the largest specialist in this field. Success of the company, with sales currently at a $11.5 million annual rate, has been based on its adoption of automobile industry tooling principles, in which metal-working machinery is designed and built to perform a specific production-part function, rather than the traditional airframe industry principle of adopting general purpose machines.

A. T. M. designs and builds its own metal-working machinery. Its unique production capacity includes skin mills for planing aluminum sheet; special planers for three-dimensional milling of spars, forgings, and beams; cavity mills for sculpture of aluminum, titanium, and high-strength steels; and a variety of hand routers, drills, and hydrohones. It has the largest aircraft liquid-honing installation in the West. This capacity enables the firm to tailer machinery to fit each job with substantial cost and time savings.

Continued on next page

aluminum sculpture milling

continued



Product of horizontal rise and fall mill, with finished wall thicknesses 1.062 in. to .025 in. and rib widths of .064 in. with special hydraulic tracing systems, tolerances of ±.002 in. may be attained.

In airframe production the sculpture-milling process may be undertaken by the following:

- Prime aircraft contractors
- Major assembly subcontractors
- Specialist sculpture-milling suppliers

Often, these three as a team may perform sculpture-milling simultaneously, on the same aircraft project. The interplay is determined by the specifics of the problem.

Airframe prime contractors may normally retain as high as 50 per cent of the work in their facilities for strategic safety reasons. Major subcontractors also may buy the sculptured skin or spar milling portions of certain assemblies when their own facilities are unavailable, or when cost considerations may justify it.

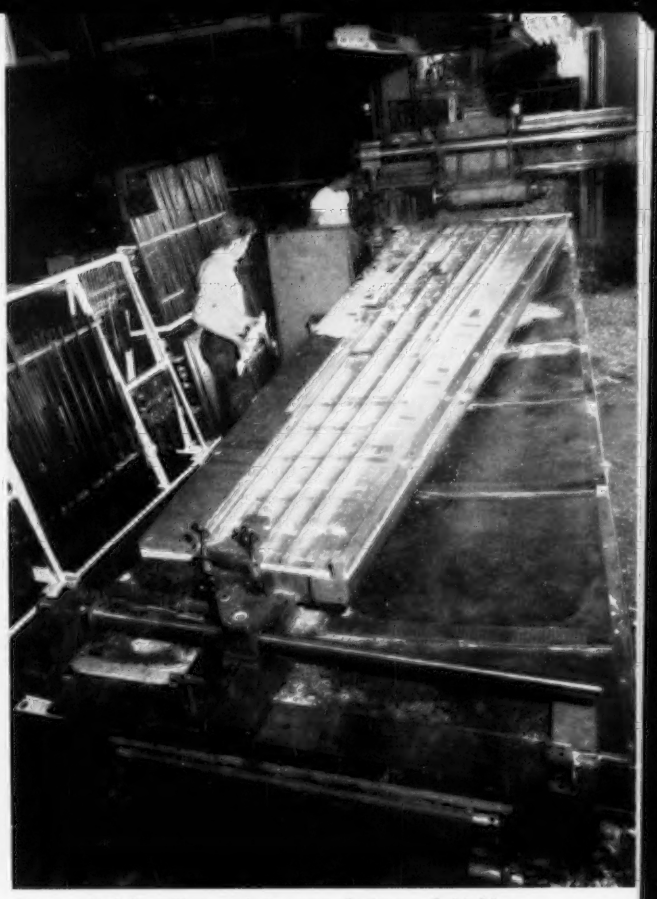
Check Cost and Cut Lead-Time

The subcontractor and the machining company are often competitors in bidding for prime contractor work. Equally as often, the airframe company lets its machining work to two or more competitors, while performing identical work in its own shop, partly as a cost-check and partly as a learning-curve determinant for large-quantity work. Yet another opportunity for the specialist is the machining of a prototype part from plate or billet, which will ultimately be scheduled for forging. The usual long lead-time needed for forging dies normally makes installation of the forged part impossible on prototype aircraft, and sometimes, even for a considerable number of production aircraft.

A. T. M. and other fellow members of this industry are well aware of the limitations of aluminum for elevated temperature applications in aircraft and missile structures. A. T. M. is already machining titanium and high-strength steel into sculptured parts, on a limited basis consistent with current applications in airframes. The company has pioneered its own techniques in spindle-speed, work-speed, and lubrication, together with the design of its own cutter shapes and materials for machining tough metals. The firm uses variable speeds and feeds in the process, and has found little difficulty with edge-cracking, molecular diffusion, or fire hazard problems reported by some manufacturers.

A. T. M. has virtually eliminated final hand finishing through the installation of a large liquid hone. This process, imported from Germany, passes completed machine parts through a fine abrasive bath to remove machining marks. The abrasive consists of aluminum oxide particles suspended in a hydraulic fluid, and propelled against the surface of the part by high-velocity air blast. The completed part need be passed through the chamber only once, yet is honed to a smooth finish in a matter of minutes, regardless of its complex shape. The "peening" action of the high-velocity abrasive particles also relieves any stresses due to machining, and thereby extends the fatigue life of the part. Another advantage of this method is the deposit of a thin layer of hydraulic film on the completed parts, which acts as a useful finish preservative and anti-oxidant during shipment and storage.

Double housing planer shown sculpturing commercial airliner wing panel, can remove aluminum at rate of 280 cu ipm.



Rise and fall mill—used in manufacture of highly stressed air-frame components.

Liquid hone machine can process parts 100 in. wide and 60 ft in length.

Aluminum sculpturing by cavity milling. Varied wall thickness and rib widths are obtained with trace tooling and micrometer reading stops on vertical motors.

SeaMaster

design of rotary mine door seal, free-fall quench, and adhesive bonding in manufacturing

by **John P. Kushnerick**, Materials Editor

ROTARY MINE DOOR

Designed into the lower hull section of the SeaMaster is a rotary mine door, operable at speeds over 600 mph, for ejection of an internally carried 30,000 lb payload.

To provide adequate clearance for the rotating door to move freely to open and closed positions under all loading conditions and airspeeds, a gap of 1 to 2 in. is necessary between door and the hull.

Strict design requirements are imposed on the seal which effects closure of this gap. It must be capable of rapid and repeated watertight connections against hydrodynamic pressures as high as 100 psi, experienced during landing and takeoff. It must be instantly retractable from the zone of conflict between the moving parts. It must maintain a seal against irregular surfaces subject to some structural deflection. It must resist attack from jet fuel, hydraulic fluid, salt water and ozone.

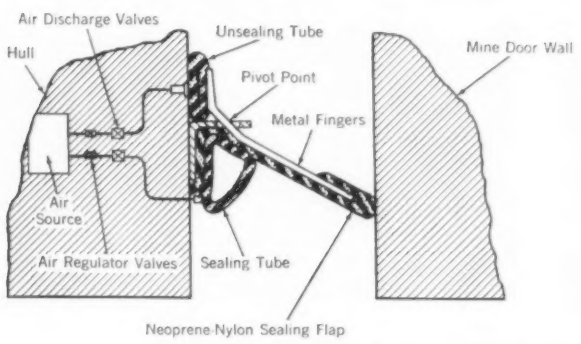
New Type Seal Needed

No existing seal design seemed capable of effecting a watertight closure under these conditions for the prolonged periods of service at sea expected of SeaMaster.

Martin devised a pneumatically operated multiple hinge type seal, which is pivoted in such a manner that it uses the high external water pressures to assist in effecting the closure. The metal hinges, called "fingers," are closely spaced about the perimeter of the mine door area. They are mounted on an angle bracket attached to the hull. A sealing membrane of oxidation resistant rubber is clipped securely to the end of the fingers for contacting the mine door walls.

The hinged fingers are pivoted to the open and closed positions by inflation and deflation of rubber tubular forms located on opposite sides of the pivot point.

The flexible pneumatic tubes are made of oxidation resistant Nylon reinforced Neoprene.



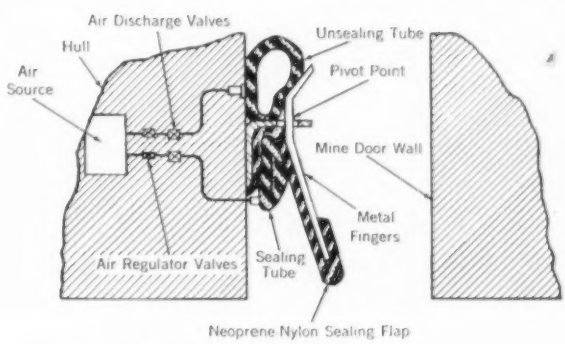


Fig. 1 and Fig. 2: Open and closed positions of the rotary mine door.

Closed Position

In the closed position, the sealing membrane is in contact with the mine door walls; in this position the door forms part of the hull contour. The tubular form below the pivotal hinges is inflated in this position and causes a pressure to direct the fingers and the sealing membrane against the mine door walls.

The external pressure to which the sealing membrane is subjected when the aircraft is in the water acts upward against the membrane and metal fingers and urges the sealing surface even more firmly to the walls of the door.

In areas where the walls are sharply contoured, the metal fingers are tapered to assist in locally conforming the sealing membrane to the surface of the door walls.

Open Position

The normal opening of the rotary mine door occurs in flight. Air is directed to the unsealing tube which exerts a pressure on the upper portion of the metal hinge fingers, causing them to pivot away from the mine door and release the sealing membrane. Valves in the lower sealing air lines are suitably arranged to allow a reverse flow in this operation. (See figures 1 and 2.)

This type of seal has demonstrated an ability to effect watertight seals on curved and irregular surfaces across a 1 to 2 in. gap with water pressures as high as 100 psi.

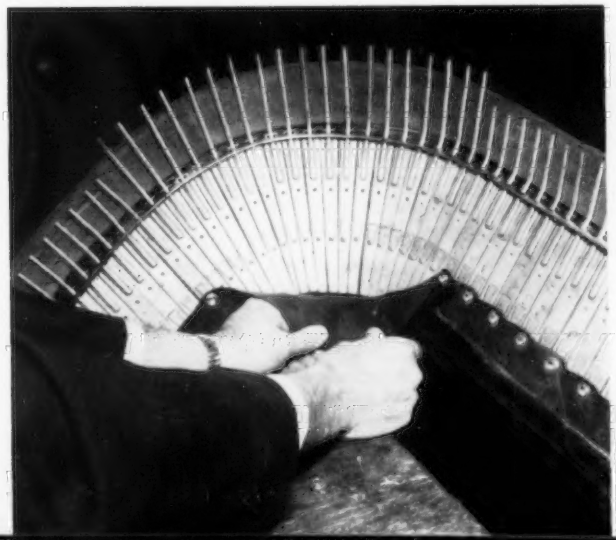
FREE FALL QUENCH

Volume production of hull longerons and wing members is promoted by using extrusions. Past policy had been to hog and mill the parts from bar stock. The final milling of extrusions is done in minutes, before heat treating, with the material in the soft condition.

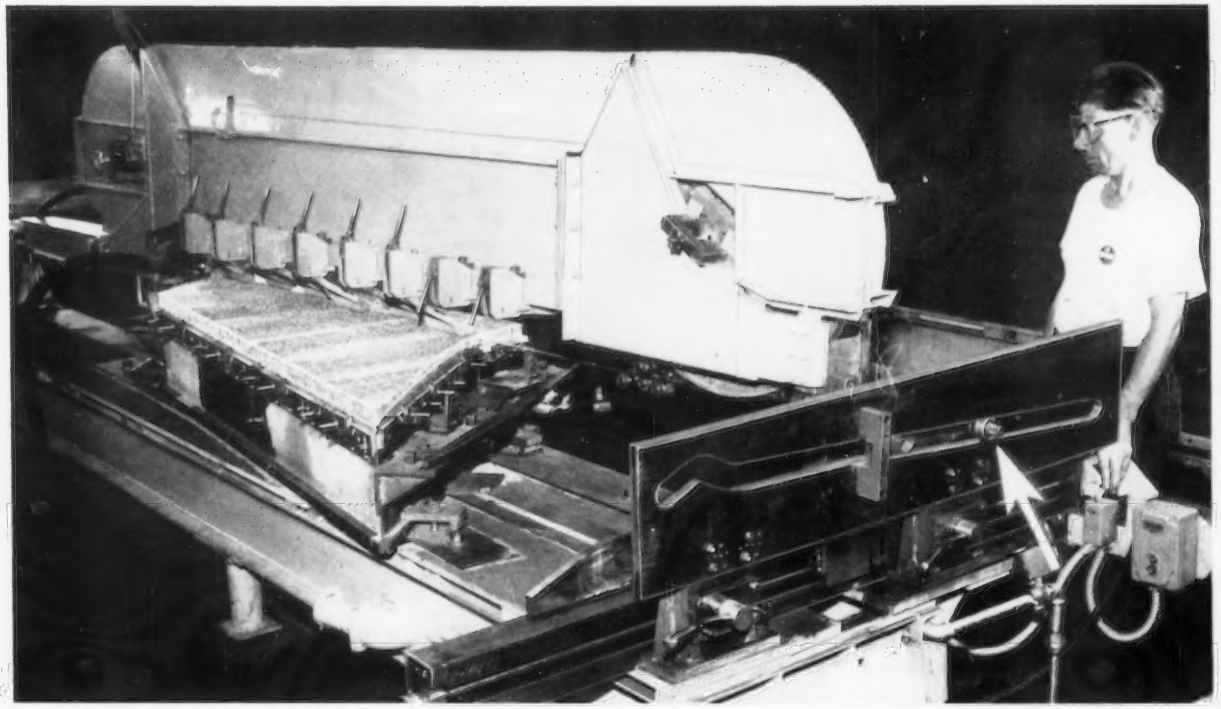
The Martin free-fall quenching has been used successfully for some time but always on smaller parts; the heavy section material encountered in the SeaMaster program was a new application toward the ultimate goal of low cost producibility.

Slow Quenching Causes Distortion

The cold water quench which follows salt solution heat treatment frequently causes distortion of parts because of the sudden, and often uneven, cooling which results. Conventional heat treating procedure had been to stack the parts in a wire basket, bring to temperature in the salt bath, then lower into the cold water quench using an overhead crane. The crane motor permitted



Attachment of the nylon reinforced neoprene seals is effected by clips on the metal "fingers."



Honeycomb billets are contoured on horizontal band saw, follower rides pre-shaped cam to establish final contour.

SeaMaster continued

a lowering velocity of about 40 feet per minute. As the hot basket was lowered into the quenching tank an atmosphere of steam was generated, some spattering of water droplets inevitably resulted. These droplets caused local variations in the cooling rate of parts with resulting local distortions. Investigation showed that 90% of all distortion was due to slow quenching in the cold water.

The free-fall quench makes use of an apparatus that allows each piece to be hung separately, properly positioned, and dropped into the quenching tank from a height insuring optimum speed and angle of entry into cold water.

Simple Mechanisms

This apparatus is simply a 14-foot pipe with hanger pins, or studs, from which parts are hung on wire loops. On one end of the pipe is a heavy counterweight which is held about 20 degrees above the horizontal when in the loaded state. Several safety devices prevent the suspended parts, and the counterweight from slipping. When the trigger pin is pulled, the 14 foot pipe rotates so the hanger pins are about 105

FM-47 adhesive is applied by rollers, amount of adhesive is regulated to 0.09 lb per sq ft per side.

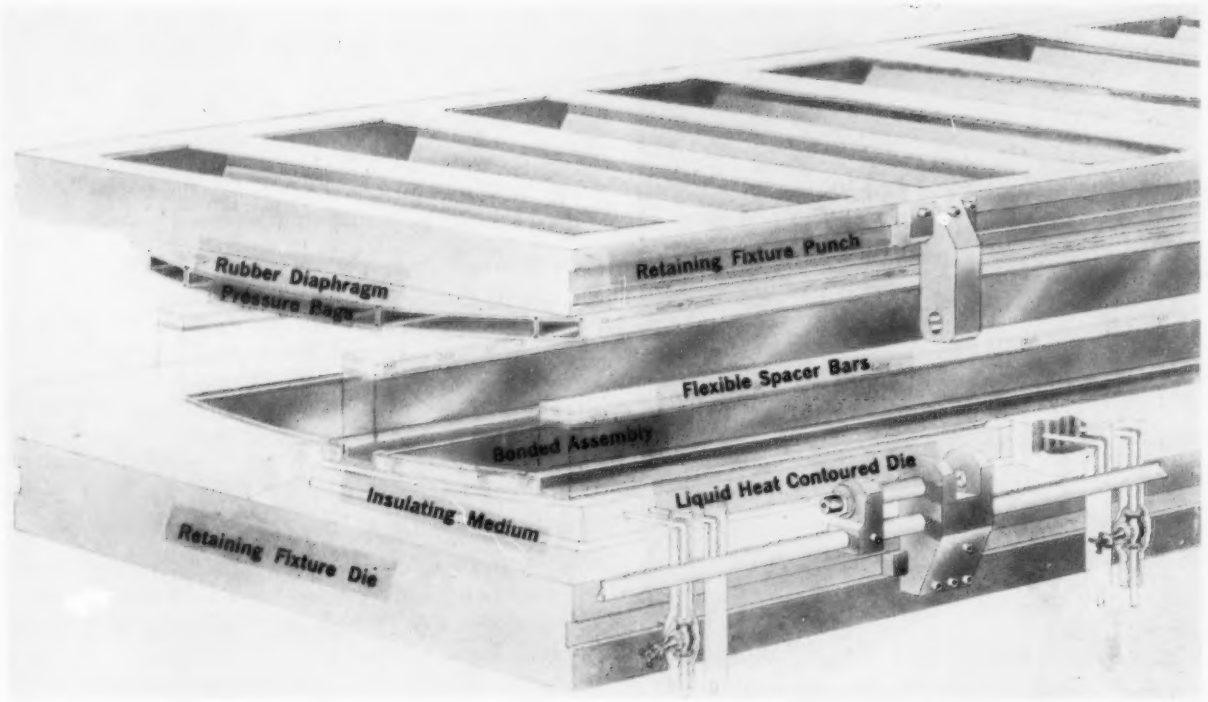


Fig. 3: Oil-heated, air-pressurized bonding fixture.

degrees below the horizontal and the wire loops slip off the hanger pins, dropping the parts into the quenching tank.

Simultaneous Entry

It is essential that parts be hung so that they cut the surface of the water with minimum splash. The lower ends of all parts should be in the same horizontal plane to effect simultaneous entry. Spacing of parts should be such that inter-part contact and resultant steam hammers will be precluded.

Speed and Angle of Entry Important

The height of the drop is important since it determines entry speed. A drop from too high has resulted in unpredictable entry angles and excessive splash; a drop from too low has also proved inadequate, due to insufficient speed.

Parts are lifted from the quench tank by a wire frame which remains in the tank as a false bottom.

Continued on next page

Wing spoiler section after removal from bonding fixture.

"Button" sample is prepared for microscopic examination of the cured adhesive.

SeaMaster continued

Part distortion during quenching was reduced to such an extent after incorporating the free-fall quench method that approximately 60 per cent of the parts that previously required hand working were ready for use when removed from the free-fall quenching tank.

ADHESIVE BONDED HONEYCOMB

Since honeycomb, and FM47 adhesive found their origins with Martin, it might be expected that the P6M would contain many adhesively bonded honeycomb parts. This is exactly the case. About 200 adhesively bonded components, 40 per cent of these primary structures, are designed into the flying boat. Contoured air foils, as well as flat bulk heads and decks are used.

The advantages realized with bonded honeycomb structures are: rigidity, thinness, lightweight, and speed of fabrication using semi-skilled labor. Since honeycomb is purchased in large, roughly contoured blocks, final contouring is done at Martin on specially designed band saws. The horizontally mounted saws generate the desired contour by riding on pre-shaped cams.

Cleaning and Coating

The skins are cleaned in hot alkaline solution, rinsed, dipped in chromic-sulfuric acid solution, rinsed again and force dried. Adhesive is applied by spraying the skin material, or by passing the honeycomb through rollers coated with adhesive. Adhesive weight is controlled to 0.09 lb per sq ft, dry weight, for good bonding. Coated parts are force dried at 225°F for one hour.

Four Bonding Fixtures Used

Bonding is effected in four separate fixtures: the autoclave, the oil heated air-pressurized fixture, the electric blanket fixture, and the hydraulic platen press.

A description of the bonding of representative parts will show the use of each fixture.

The top and bottom "skins" of the horizontal stabilizer are in reality honeycomb sandwich structures (Fig. 4). Each stabilizer surface is bonded in two steps. First, the adhesive coated core and skins are arranged in sandwich fashion in a contoured fixture. A blanket is drawn over the lay-up and the air beneath the blanket is evacuated to 14 psi; this holds the parts in place. The entire assembly is then positioned in a steam heated autoclave, brought to 330°F, and cured at 60 psi autoclave pressure for 30 min.

After this phase of the curing cycle the part is manually removed and allowed to cool only slightly before it is given the final cure.

Final Cure

The final cure is accomplished by placing the stabilizer component in an oil heated press fixture (Fig. 3). Shell Volta 972 oil is circulated through passages in the base of the fixture at 400°F until the entire assembly reaches 330°F. At this temperature a bonding pressure of 70 psi is applied by a rubber air bag. Temperature and pressure are maintained for 30 min. The bonded part is cooled under pressure in the fixture by circulating cold oil through the passages.

The outer wing trailing edge (Fig. 4) is about 136 in. long and 49 in. wide; its skins are step tapered by chemical milling. This component is bonded in one step in an electric blanket bonding fixture. The fixture is a slight variation of the oil heated press, in as much as heat is supplied by passing electricity through nickel heat-

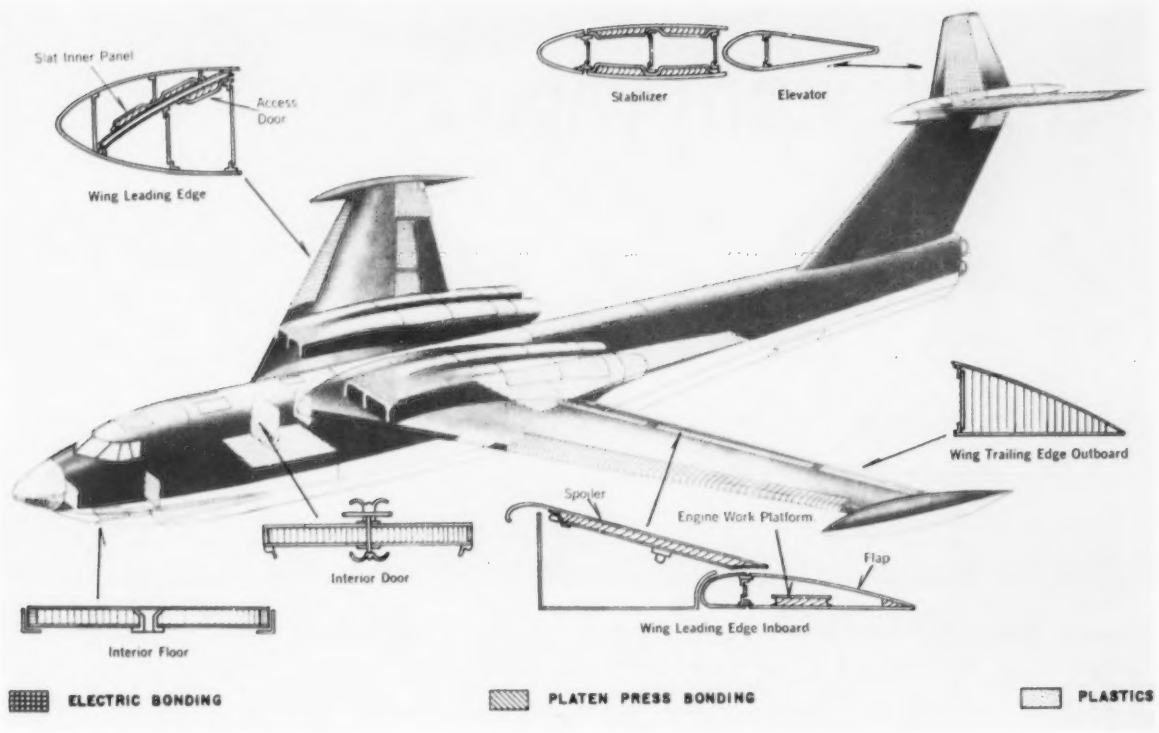


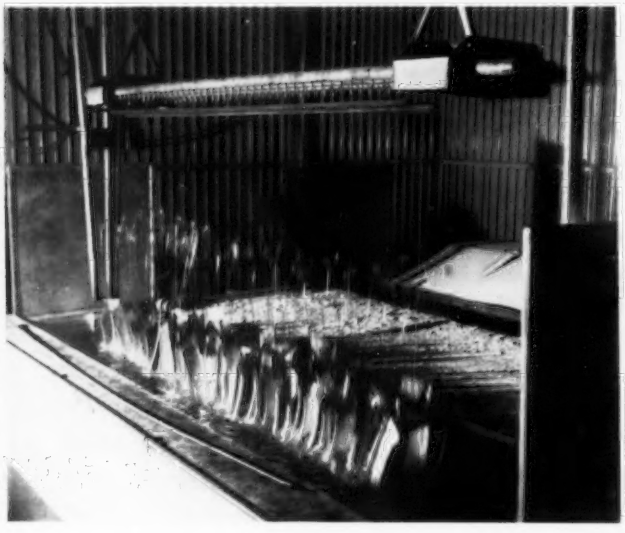
Fig. 4: Areas where honeycomb sandwich is used in SeaMaster.

ing elements. Left and right wing components are bonded simultaneously in the same fixture.

The honeycomb panels used as flooring in the flight compartment, equipment compartment, tail compartment, and as watertight bulkheads and doors throughout the aircraft, are bonded in flat platen presses. Cure cycle is 330°F for 30 min. at 100 psi.

Testing

Adhesive bond quality is evaluated by destructively testing in tensile, shear, and peel, the first production piece of each primary and secondary structure. Subsequent quality is maintained by cutting a test button from the trim area of each component and examining the glue line under a microscope.



Parts are shown dropping from hanger pins in free fall quench. Distortion caused by slow quenching is evident in photo above.

phenolic impregnated silica fabric

sacrificial heat material offers high temperature design possibilities

by John P. Kushnerick, Materials Editor

Given a choice between a metal, UTS 150,000 psi, and a non-metal, UTS 12,000 psi, the structural engineer would in most instances consider the metal first.

From the very beginnings of flight, when the legendary Icarus had a disastrous flight because he used an organic material in coping with a heat problem in flight, non-metals have not enjoyed great popularity in air frame construction.

The situation is changing completely as a result of the introduction of the factor of speed (Mach 9, where gas temperatures reach 8000°F). No known solid is stable at this temperature, strength must be sacrificed to heat resistance, and a compromise attained to cope with the high temperature environment.

The very limited state of present missile and rocket development places unreasonable demands on our structural materials. We know we will encounter temperatures no material could long endure without being consumed.

One common way of coping with this situation is to utilize non-metal insulating and refractory materials, where a sacrificial concept is employed. In this type of structure (usually laminated) the extreme temperatures cause a rise in surface temperature of the material and gradually consume the outer layers, but a high thermal gradient (poor heat conductivity) protects the inner layers. These structures are suitable for only short durations; but short durations, one shot exposures, are all that are required of our present rocket parts and re-entry vehicles.

New Entry

One of the more promising recent entries to the growing list of non-metallic sacrificial heat resistant materials is a product called Astrolite. It is a fibrous silica cloth-phenolic impregnated material which in laminated form has out-performed stainless steel in burn-through tests at 4500°F.

In the manufacturing process ordinary glass cloth, which contains about 55 per cent silica (SiO_2), is subjected to an acidic leach to remove the non-siliceous constituents and leave a woven fabric of virtually pure (98 per cent) vitreous silica. The heat resistance of (SiO_2) is well known from its use in refractory materials. Impurities are removed after the fabric has been woven because SiO_2 fibers do not readily lend themselves to weaving.

Characteristics

The chief characteristics of the new silica fabric-phenolic that have stimulated interest are:

- Resistance to heat erosion, long burn-through time.
- Resistance to thermal shock.
- Resistance to high temperatures, (ie.) good variation between hot side and cold side temperatures.

Laminate of silica fabric and phenolic only charred after 42 sec exposure to 5000° F blast.

Steel plate of same thickness (1/2 in.) burned through completely in same test.

- Good physical properties for a refractory material.

Viscosity-Vaporization Curve

Probably the one property that contributes most to high burn-through times is that the pure silica fibers melt to a viscous fluid at high temperatures and subsequently vaporize without an appreciable change in viscosity.

The high viscosity limits blow-off of the melted material and the vaporization tends to cool the surface and thus retard burn-through. Most other refractories become very fluid at high temperatures and are blown away in large droplets.

Melting occurs about 3100° F and vaporization at a slightly higher temperature.

Realistic Claims For Phenolic

The resin used in Astrolite is a high-temperature phenolic, modified to give improved wetting and impregnating properties. The resin itself will not withstand continuous temperatures over 500° F without serious breakdown. This temperature is generally recognized as being close to the upper limit of resistance to degradation for a carbon to carbon bond in organic materials.

Burn-Through

Carbon and graphite have surpassed silica fabric-phenolic laminates in burn-through times. These two materials however have drawbacks which seriously limit their application to aircraft and missiles. They are extremely brittle. They also possess a high heat conductivity which enables their "cold-side" temperature to reach 1000° F almost instantly when a 4500° F heat source is applied to the hot side. While this type of material does not burn through itself, it affords very little protection to critical components it might shield.

Loss of Natural Lubricants

The physical properties of silica fabric are not as high as those of glass cloth because the leaching and drying process removes the natural lubricants which would contribute a great deal to over-all strength. Silica fabric may be punctured easily even though pull strength is fair to good. A finish similar to Volan A is presently under evaluation to increase the physical properties.

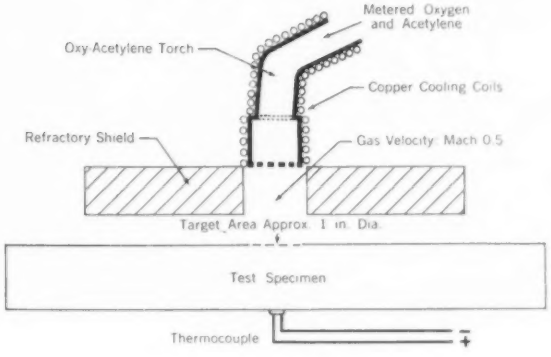
Surface Treatment Required

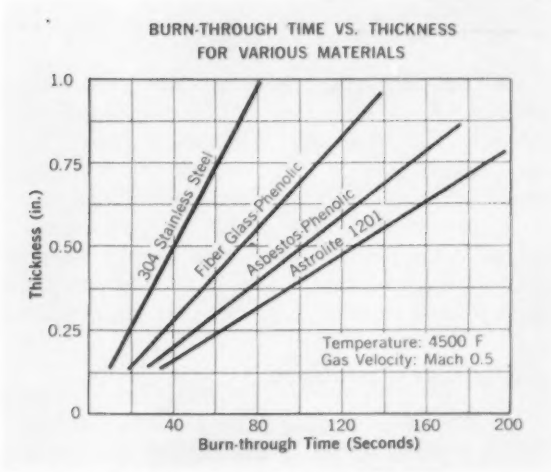
During processing and weaving, glass filaments are subject to severe abrasion from one another and have a tendency to become fuzzy. This is especially true of leached glass cloth.

Resins do not naturally adhere well to glass or SiO_2 fabric. The modifications to the Astrolite phenolic resin cope with this in part, but the surface treatment which the fabric receives should

silica fabric continued

APPARATUS FOR TESTING LAMINATES





Good burn through properties of silica fabric reinforced phenolic are shown in line furthest right in above chart. (Astrolite)

also assist in some measure to provide adequate adhesion.

Surface treatment should serve at least two basic functions: provide lubrication, and act as an intermediary to provide adequate resin-cloth wetting and adhesion.

Machining

Silica-phenolic laminates can be machined using techniques similar to those used for fiber glass laminates. Carbide and diamond tipped cutting tools are most practical. Abrasive cutting wheels of the same type used for masonry are adequate. Drilling with high speed drills may be performed but drills will become dull rapidly.

COMPARISON OF DENSITY AND THICKNESS FOR 100 SECONDS BURN-THROUGH

Material	Density (lbs./cu ft)	Thickness Req'd. (In.)	Weight‡	Weight Ratio*
Stainless Steel (304)	489	1.15	47	15
Fiber Glass Phenolic	108	0.63	5.67	1.75
Asbestos-Phenolic	105	0.47	4.12	1.25
"Astrolite" 1201	102	0.39	3.32	1.00

* Astrolite being the lightest in weight was taken as base one (1.00).

‡ lb/sq ft/100 sec burn-through thickness.

ROOM TEMPERATURE PHYSICAL DATA OF TYPICAL PRESS-MOLDED SILICA FABRIC-PHENOLIC LAMINATE

Flexural Strength	20,000 psi
Flexural Modulus	3.0×10^6 psi
Compressive Strength	23,000 psi
Tensile Strength	8,000 psi
Izod Impact Strength	97 in.-lb./in.
Water Absorption	1.5 per cent
Barcol Hardness	50
Resin Content	30 per cent
Density	100 lb/cu ft

Curing Cycles

Laminates may be cured in matched pressure molding or bag molding processes. Bulk fibers are also available for fillers in molding compounds.

Resin flow properties may be regulated for curing at pressures from 15 to 100 psi and higher for laminates. Closed mold parts have been made at pressures as high as 1000 psi.

The resin may be cured at 300 to 350° F. Time of cure varies with part thickness, 15 min is minimum cure time.

Availability

Astrolite is most commonly produced in cloth Styles 164, 182, 183, and 184; Style 182 predominates. Commercial impregnators equipped to process the silica fabric are American Reinforced Plastics Co., Coast Mfg. and Supply Co., Cordo Molding Products, Narmco Resins and Coating Co., Rez-Coat Sales of Calif., and U. S. Polymeric Chemicals, Inc.

Thermal and mechanical properties of laminates are not altered by exposure to high order neutron, gamma, and deuteron bombardment for short periods.

Laminates resist attack by acids and mild alkali.

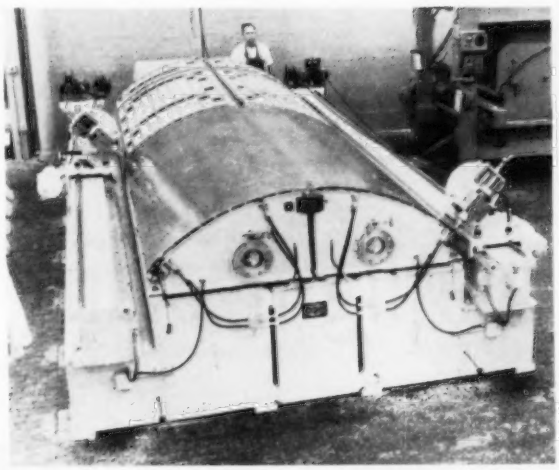
a glance at some fixtures used in manufacturing the Titan

ICBM tooling

First manufacturing photos of Air Force's Titan ICBM, being built at the Martin Co., Denver, Colorado, reveal representative portions of the precision welding tool installation reported as the largest engineered in this country. Designed and installed by the Air Reduction Co., in conjunction with sub-contractors, the facilities include automatic welding equipment as well as supporting fixtures, rotation devices, and loading mechanisms. Inert gas-shielded arc-welding is utilized to insure integrity of welded joints.

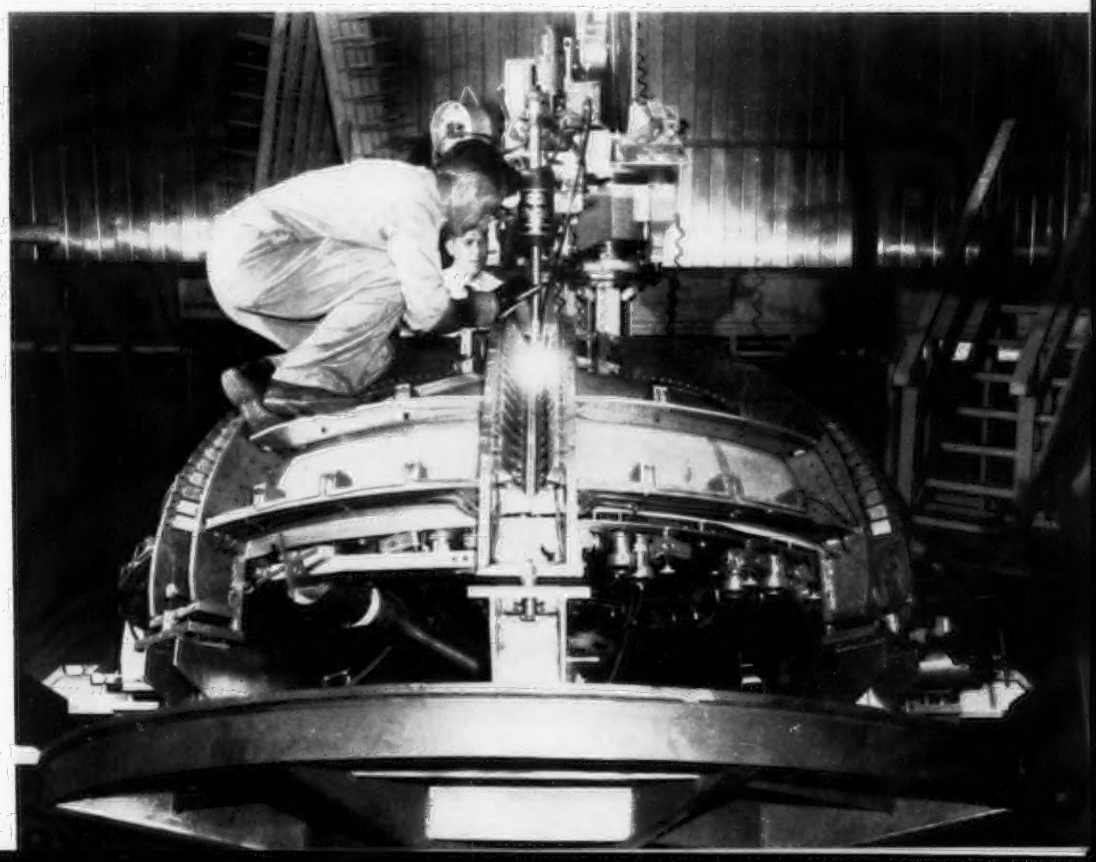
Arc-welding processes are more easily adapted to automatic machine welding than the gas flame. The welding head in most of these processes carries one electrode and moves along the work piece at a constant rate. The welding rod, usually a wire is fed into the shielded arc.

Titan is a two stage ICBM, still to be proven, and is powered by a first stage rocket reported to produce in excess of 300,000 lb thrust. The second stage rocket engine should produce about 60,000 lb thrust.



Automatic milling machine is shown preparing edges of curved aluminum plate of cylindrical section prior to assembly by welding. ▶

Elaborate turntable clamping fixture is shown holding "orange peel" sections during the assembly of the aluminum alloy fuel tanks by Heliwelding process. ▼



Tri-Pacer, top unit sales (1,101).

Apache, top dollar sales ($10.5 million).

manufacturing the light plane

Piper reverses a trend, cuts military sales and ups production; standardization, assembly line procedures decrease unit costs

by John P. Kushnerick, Materials Editor

At a time when aircraft manufacturers have come to rely more and more on government funding, Piper Aircraft Corp. has made an effort to reverse the trend and rid itself of the "vagaries of military spending and cutbacks."

While decreasing military sales to less than one-half the 1956 figure (7.5 to 3.6 per cent), Piper upped 1957 sales by $1½ million.

Big Business in the Country Store

The atmosphere is almost what you would expect in a country store, but Piper is big (1957 sales $26.6 million, total units produced 2335) and getting bigger. Without the benefit of large military sales the company has clung to third place in "general aviation" production (non-military, non-commercial), "topped only by Beech and Cessna who each bank on 40 to 50 per cent military sales."

The Secrets

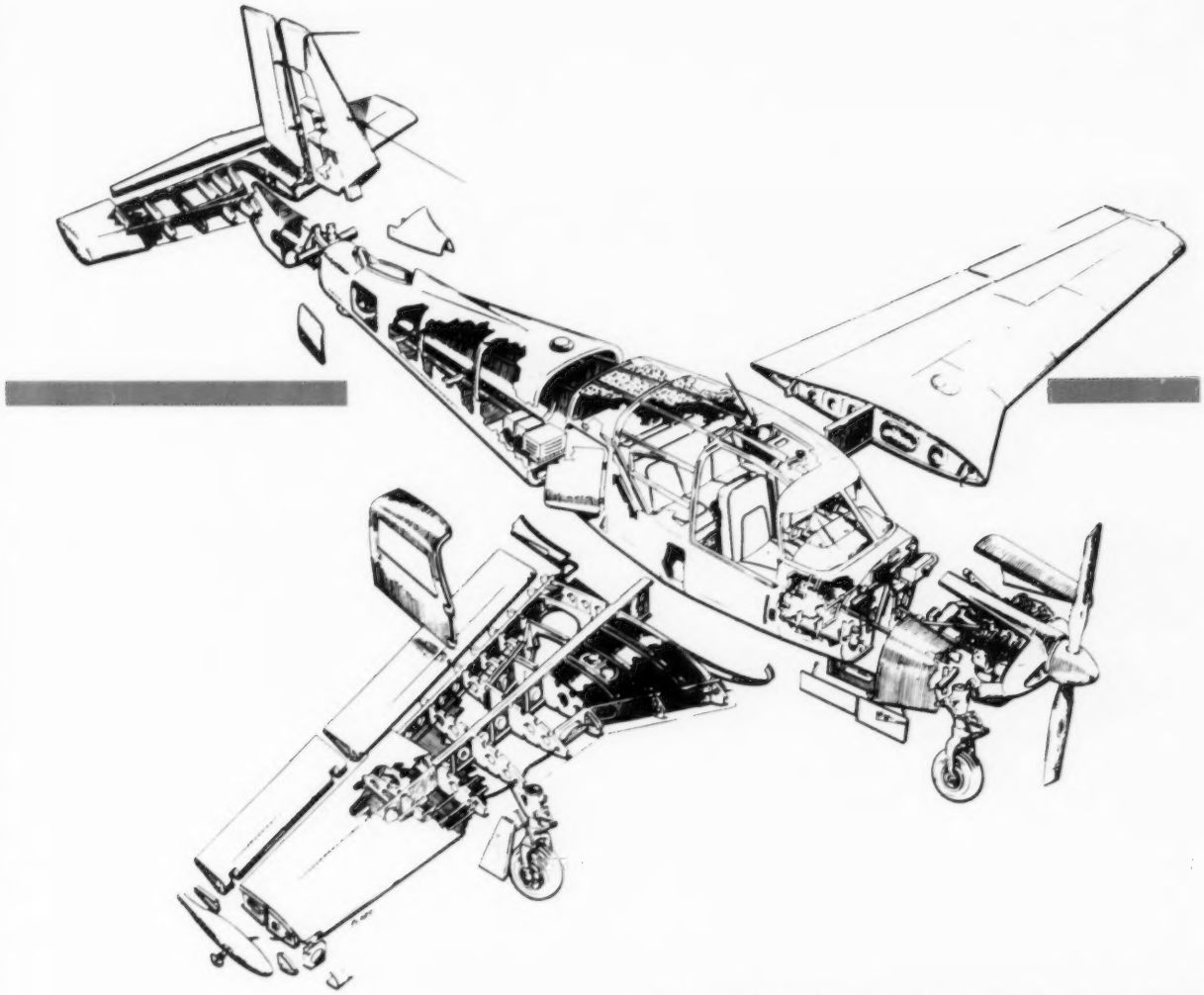
The secrets behind the leisurely pace that has resulted in production that tops all general aviation manufacturers with 146,000 units in 30 years of successful operation are: planning, standardization, and job know-how.

Three of the five models currently being produced retain the welded steel tubular fuselage. Among these is the Tri-Pacer, which became Piper's "bread-and-butter" plane in the post-war years and still accounts for the highest unit production (1101 of 2335 total units in 1957).

Production begins in the tube shop, where the ends of the steel tubes are nibbled to standard shapes for clamping in standard fixtures and welding into the basic fuselage shape. The fuselage frames then move down an assembly line on an overhead mono-rail, claimed to be the first put into use in the aircraft industry.

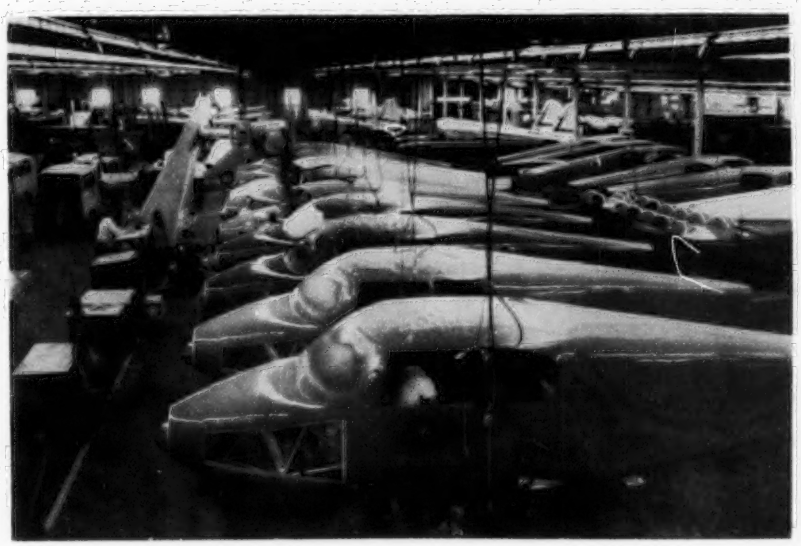
The plant is a study in the use of standard jigs, rotatable fixtures, and conveyor lines. Mass production procedures have been adapted to techniques not unlike those used in classical model plane construction.

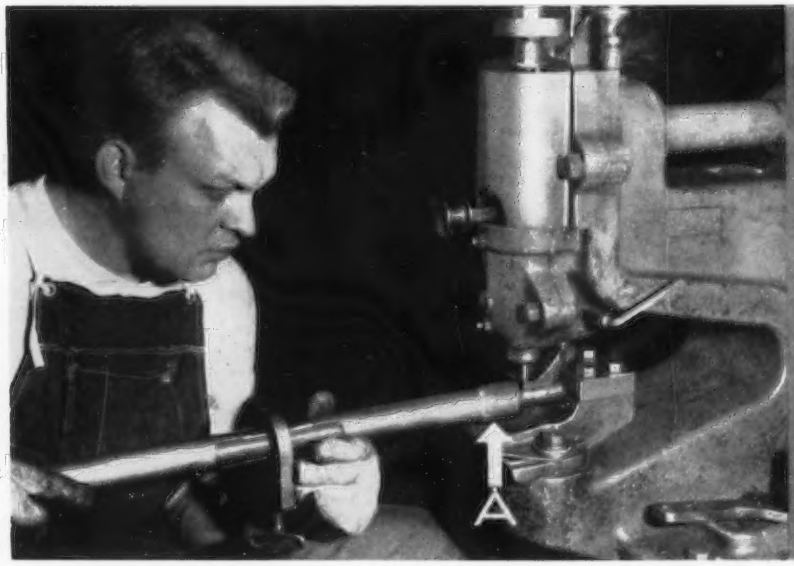
Each step in the assembly line is performed by local workers, each skilled in a particular phase of aircraft manufacture. As a result, Piper aircraft are manufactured almost totally at the Lock Haven site. Only the power plants (from nearby Lycoming), landing gear, brakes, and cockpit instruments are fabricated outside the plant. *Continued on next page*



Design details of the Comanche show deep main spar which gives good strength, swept wing-roots which provide optimum air flow at low speeds.

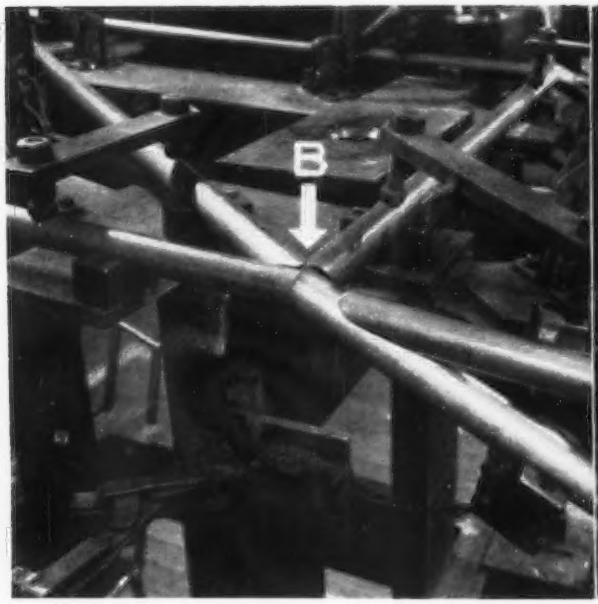
Apache paint shop shows evidence of volume production, standardization, and efficiency. Overhead lines supply air to individual painters. Planes are mounted on dollies and moved down the line on a rail car. About 60,000 sq ft of floor space are devoted to Apache final assembly area.



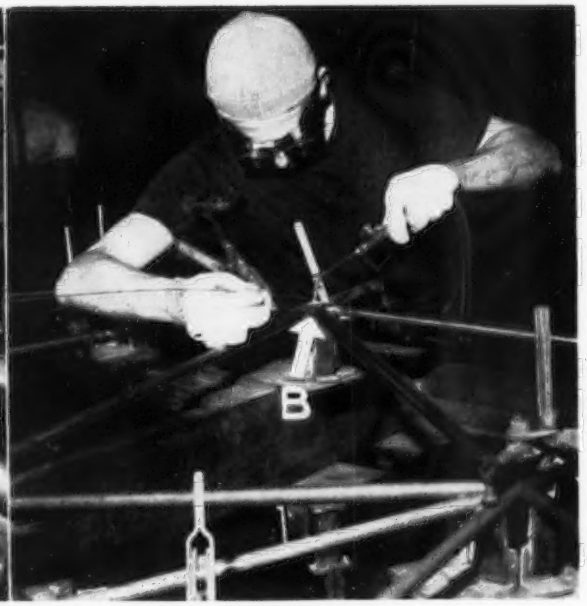


Nibbler machine is used to contour ends of steel tubing (4130 and 1025), still used as the fuselage frame work in three of Piper models. Tubing is marked with a number code, cut to length, clamped in a pipe collar, then nibbled to one of several standard contours.

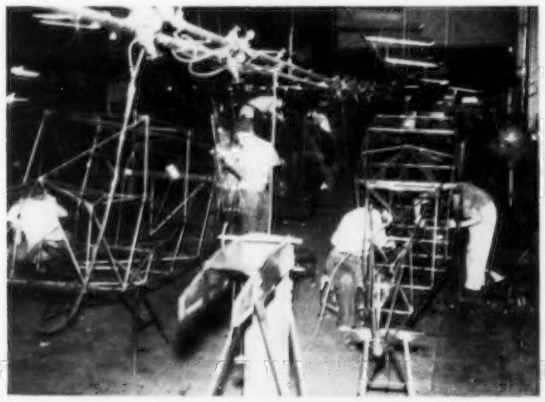
Nibbled tubing assumes the pre-shaped contour of the collar fitting clamped over it in the nibbling process. Entire process takes 15 sec. Piper claims to have developed methods for nibbling tubular shapes judged impractical by other manufacturers.



Neat clusters are formed by clamping nibbled tubing in standard welding fixtures. All parts are coded to correspond with markings on the fixture.

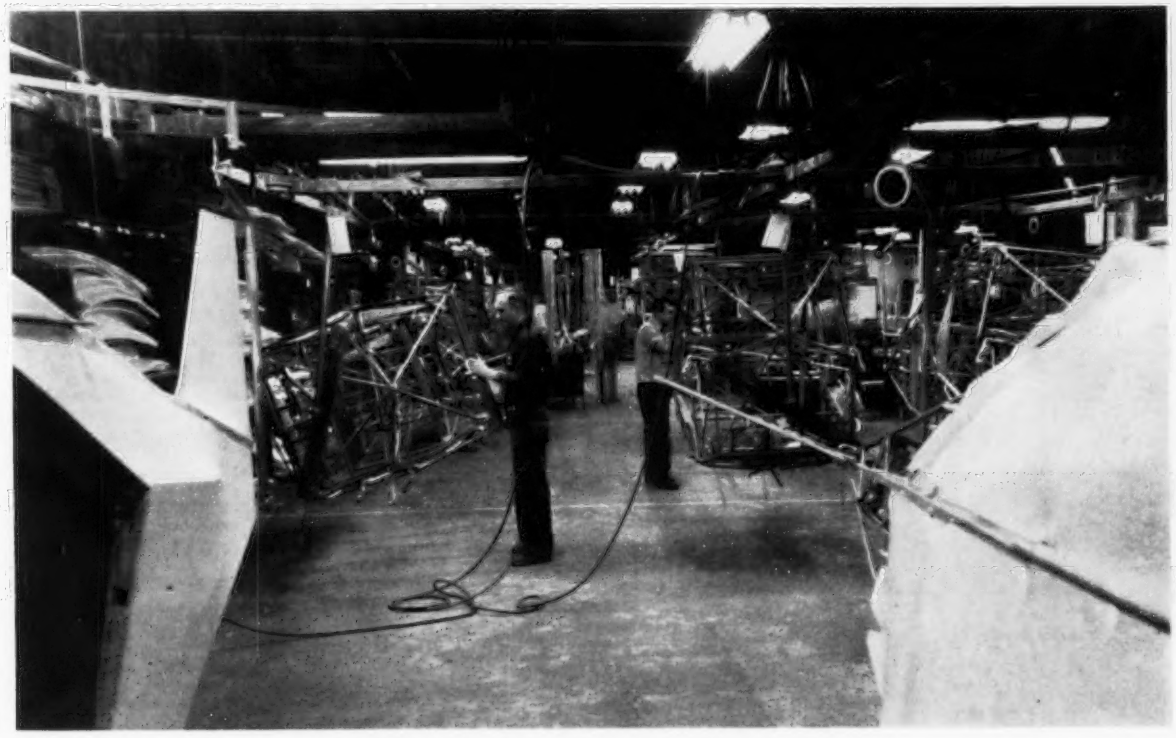


Clusters are joined by oxy-acetylene welding. Welding gas is supplied from a central source and piped to the welding stations through overhead lines.



Tri-Pacer fuselage takes shape on welding horses as welded sections are pieced together. Overhead oxy-acetylene lines are apparent in upper left. All weldments are checked for cracks by magnetic particle inspection. (Magna-Flux).

Overhead mono-rail is used to move corrosion treated fuselage assemblies down production line. Mounting makes the fuselage rotatable through 360 deg. for easy installation of control pulleys and cables and application of fabric. Fabric surfaces are treated with fire resistant butyrate dope, metal surfaces with enamel.



Tri-Pacer

The Tri-Pacer construction is typical of a welded tubular fuselage aircraft. "Chrom-moly" 4130 steel is used in areas subjected to high loads, while 1025 steel is used in most other areas.

The fuselage is made to resist corrosion by the application of zinc chromate and a coat of nitrate dope sealer. In areas where fabrics come in contact with the steel, a third coat of dope resistant lacquer is applied. The tube interiors are coated with linseed oil to inhibit corrosion.

The wing framework consists of riveted aluminum ribs mounted on extruded aluminum spars supported by tubular drag and compression struts and stainless steel drag wires. Aluminum sheet is used to form the leading edge and aileron false spar. An ash bow is used in the wing tip.

Wings are attached to the fuselage by hinge fittings on the upper fuselage members and by lift-spar struts which are bolted to the lower fuselage members and to the wing-spar fittings.

The empennage is also constructed of welded tubular steel with steel channel ribs. Control surface hinges have bronze bushing inserts.

continued

Rotatable mounts on Apache line facilitate installation of landing gear, engine mounts, flight controls, and fuel tanks

After landing gear is attached planes move down the line on own wheels. Power plants are obtained exclusively from nearby Lycoming Aircraft. After wings are attached the plane is removed from the plant for final adjustments.

Comanche - Apache

Piper has added the low-wing, single-engine Comanche to its 1958 line. Like the multi-engine Apache, it represents a departure from the welded tubular frame construction. The fuselage is all metal monococque construction. The entire horizontal stabilizer is a movable control surface with a self compensating tab. This type of "flying tail" is now common on most high performance military aircraft.

The Apache fuselage is composed of four basic units: a sheet metal tail cone, a cabin section, a nose section, and a tubular steel structure which extends from the tail cone to the nose wheel. This steel structure is designed to absorb the high loads imposed on the center section.

Apache wing structure consists of a large stepped-down front spar, a rear spar, lateral stringers, ribs, and stressed skins. Attachment is effected to the fuselage at the tubular center section. Main spars are bolted to each other in the center of the fuselage. This arrangement eliminates the necessity of heavy wing-hinge fittings and elaborate carry-through structures in the fuselage.

Apache is the lowest priced multi-engine business aircraft on the market, and accounts for the largest dollar sales at Piper ($10.5 of $26.6 millions).

Comanche has been introduced as an extension of the basic planning philosophy at Piper, "give the public what it wants": a high performance, low-wing, single-engine, business, pleasure aircraft.

history of producibility at Boeing

share-the-experience program based on consultations with specialists realizes savings which stretch the defense dollar at Wichita division

Whether this program is called share-the-experience, design for producibility or production design, it boils down to an organized drive to simplify production and ultimately stretch the defense dollar.

What basic philosophy is most conducive to more efficient production through simplification? It is that of "synergy": defined as the cooperative action of two or more organs within a body.

The spirit of implied cooperation, however, often becomes diluted in running through the maze of administrative channels. Lack of cooperation may not necessarily be intentional but may easily stem from poor communications between the parties involved. Specifically, due to an ever-changing personnel picture, as well as the constant development of new production procedures, it is difficult to keep designers abreast of current production practices. It is equally as difficult for Production to know what is being attempted in Engineering, to suggest alternate methods of manufacture.

The recognition of these difficulties brought about a "share-the-experience" program at Boeing, Wichita, to promote greater producibility. Organized by E. O. Weining, this program was applied successfully in producing the B-47 and the B-52; it has operated to screen new design as well as to improve existing design. This program is more than a routine liaison system; it is a dynamic, working partnership between Engineering and Production.

Structure of Program

The share-the-experience program at Wichita consists of two major phases:

1. To give design engineers continuous "on shift" training.

2. To provide engineers with a "consultant" service in design for production.

In the training program, four instructors are continuously engaged in research, and in the development of training material. Lectures are presented twice daily. Each engineer attends once every three weeks. Instructors cover such subjects as casting and forging processes, dimensioning and tolerancing, and metal bonding. New manufacturing processes are discussed as they develop.

In addition to the regular lecture series, shop tours are given as part of this training program. Lectures are supplemented by training films of Wichita facilities as well as those supplied by technical libraries. Emphasis is placed on details of current manufacturing methods and processes, as they relate to specific machine capabilities and limitations. In brief, an engineer is provided with the background which will assist him to deliver an efficiently "producible" design.

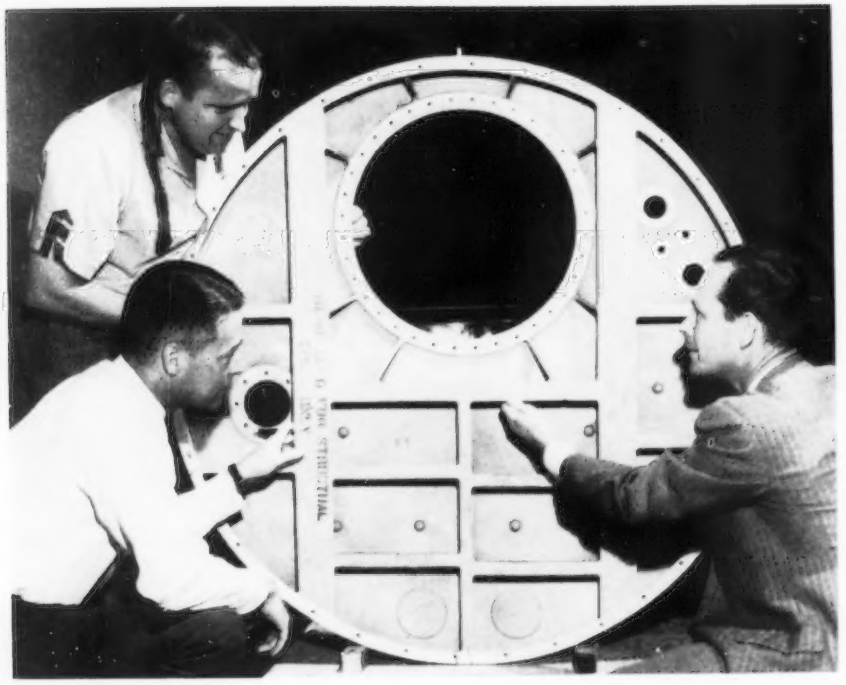
Response to the Program

The popularity of this program was revealed through a survey among participating engineers. Of 300 individuals who had completed the first 30 sessions of the program, 99 per cent indicated the training was of benefit.

In the consultant-service part of the program, eleven specialists and technicians have acted as advisors to the design engineers. Six of these were brought to the project from key positions in the manufacturing shops. They avail their experience in sheet metal fabrication, tube bending, tool design, tool and production planning, metal bonding, equipment engineering and machining. They answer questions, provide cost comparisons, offer guidance, suggest design improvements, and assist in solving associated prob-

. . . at Boeing

continued



A. Chapel, structures engr., standing; G. Wattles, B-47 power plant engr., left; and E. Swing, producibility casting consultant inspecting results of three-way cooperation

lems. Five others are specialist engineers to advise on casting design, forgings and extrusions, design manual and specification coordination, and over-all design-manufacturing problems.

Typical Results of Program

1. During a B-47 modification project, Wichita engineers had to design a new bulkhead for drop tanks. In the course of resulting consultations between engineers and manufacturing personnel it became apparent that a single large casting could be produced to replace an assembly made of about 40 parts.

2. Also on the B-47 Assist Takeoff racks, which accommodate 30 bottles of rocket propellant, a change in the design of ignition terminal posts, projected over contract quantity, eliminated some 3,000,000 parts. This resulted in savings of $169,000.

3. When a study was initiated to investigate the excessive rejection rates of a B-52 spoiler support casting, a need was ascertained for more practical dimensioning. Upon review of drawing with the vendor, it was revealed that the cost of the casting would be reduced from $72.50 to $32.50. With a subsequent order for 144 of these the cost of the unit was further reduced to $9.47.

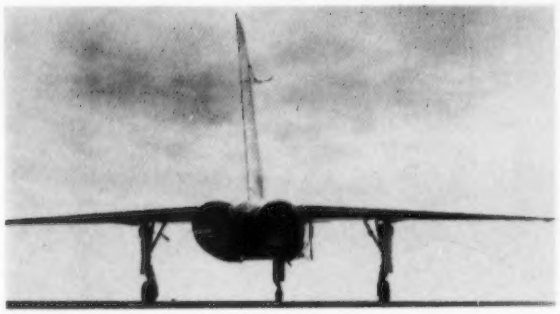
4. Another review and change of "blind" rivets on the B-52 resulted in overall savings of $57,260.

5. $9,100 were saved through a change in machining operations on a beam assembly.

6. A minor change in the configuration of a stainless steel component eliminated a "springback" problem, reduced rejection rates and amounted to a projected savings of $9,700.

7. In the case of the B-52 landing gear steering ratio selector casting, original dimensioning of a casting created a tolerance build-up. The design was changed to enable boring of three holes from one side rather than two from one and the third from the opposite.

8. The main landing gear bulkheads of the B-52 have also been reviewed and revised, in an effort to reduce production costs. Through the blocker-type die forging method developed at Alcoa's Cleveland works, where Air Force's 50,000 ton press now operates, total machining man-hour requirements have been reduced by 62 per cent. The amount of aluminum originally needed for one set of bulkheads now suffices for eight.



plastic tooling - epoxies move in

thermosetting resins prove versatile as laminates or castings

by A. E. Beckley,
Methods & Process Supervisor
Avro Aircraft Limited, Canada

What's new in plastic tooling? Epoxy resins: the most recent addition to the tooling plastics family. They are thermosetting, adaptable to laminating or casting techniques. Though initially more expensive than their phenolic and polyester counterparts, epoxy resins possess the following characteristics which may account for their recent prominence:

- Good dimensional stability after room temperature cure
- Improved physical properties
- Compatibility with a variety of filler materials for use in laminated or molded tooling
- Adaptability to smooth, accurate surface reproduction without elaborate finishing
- Excellent adhesive properties for facing other tooling materials.

Why Use A Master Model?

The relentless progress of engineering design which has produced the supersonic breed of aircraft and missiles has brought with it many attendant manufacturing problems. One of the most seriously felt of these problems is the requirement for increased accuracy.

To achieve aerodynamic smoothness in the airframe envelope it is mandatory that tolerance call-outs be observed through all phases of fuselage manufacture, particularly in stamping, forming, and drilling the sheet metal.

Glass cloth tracings, and accurately shaped metal templates have the distinct disadvantage of reproducing shapes or dimensions in only one plane. To quickly and accurately check parts to three dimensions the master model or mockup has proven an invaluable tool to the shop man. The contour of the model is maintained to the inside skin line and formed parts are simply laid on to check the contour.

How To Make The Master Model

The master model is made in five basic steps (Figs. 1-2):

1. Precisely marked master contour templates are cut and machined from metal jig plate and mounted at correct station positions on a rigid steel or aluminum alloy center post.

2. Metallic tie rods are strategically fastened in position about one inch in from the template circumference.

3. Bronze or brass mesh is wrapped around the model between templates, using the tie rods for support.

4. Epoxy resin with asbestos filler is mixed to the consistency of putty and troweled onto the wire mesh. The build up is taken to within 1/10 in. of the template contour.

5. The final coat of epoxy facing resin is applied to the height of the contour templates. After curing, the finish coat is sanded and splined in with the templates. All relevant station and trim lines are added and the finished model is ready for use as a master pattern for the manufacture of other plastic tools or airframe parts.

Why Use Epoxies?

The general advantages of epoxies over

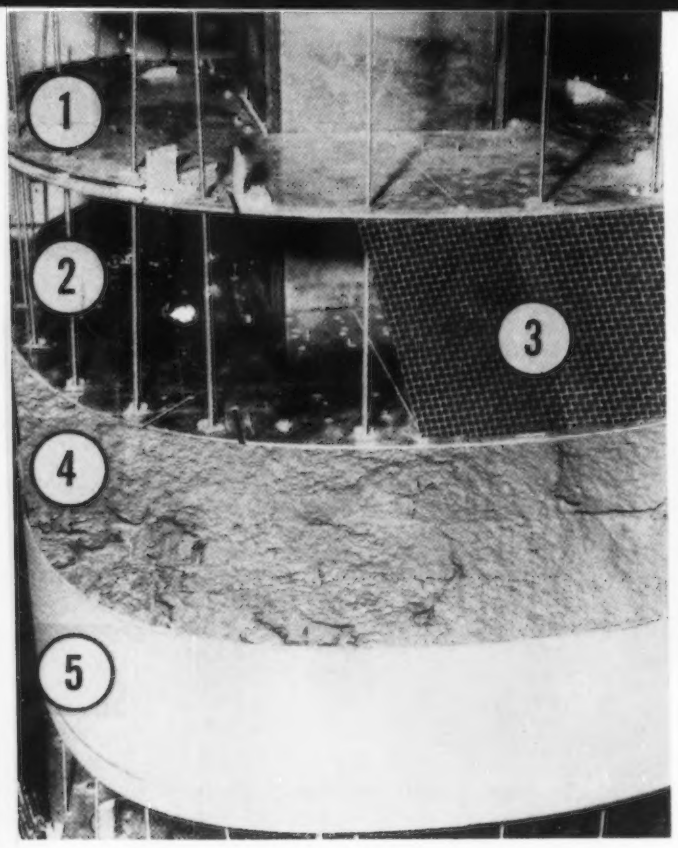


Fig. 2: Finish coat of epoxy resin is applied to a master model with a trowel to the height of the master template.

Fig. 1: Five major steps in fabricating a master model. See text, "How to make a master model."

epoxies move in

continued

other tooling plastics are listed in the opening paragraph.

Prior to the adoption of this form of construction, master molds were built from plaster, or phenolic foaming resins with plaster finishes. The hygroscopic nature of plaster made it extremely difficult to avoid subsequent surface cracking. Also the slow drying and complicated pouring technique required for foaming resins were time consuming and expensive. Earlier still, patterns were made of hardwood, this method too was very time consuming and the durability and dimensional stability of the product were unsatisfactory.

Other Tooling From Epoxies

Epoxy resins find their widest usage as trim templates, assembly jig drill baskets, and routing templates. All of these tools are made by the laminating process, wherein successive layers of resin and glass cloth are built up over a master model. Each layer of cloth and resin is allowed to harden before application of successive layers. The complete build-up is allowed to air cure for 3 to 4 hr before handling and 24 hr before being used as tooling.

The use of the supplementary tooling made in this manner facilitates locating trim lines, drill bushings, and access holes. Extensive layouts, drilling, reaming, and cutting operations normally required with comparable metal tools are eliminated.

The excellent adhesive properties of epoxies are often utilized for tooling like the stretch form block in Fig. 3. In this case the epoxy resin is cast as a surface layer ¼ to ⅜ in. thick over a Kirksite core. For this type of construction a reverse plaster pattern (splash) is made over the master model. The surface thus reproduced has a minimum of errors. The reverse splash pattern is used as a mold for reproduction of the core pattern and also for the finish casting of resin onto the core.

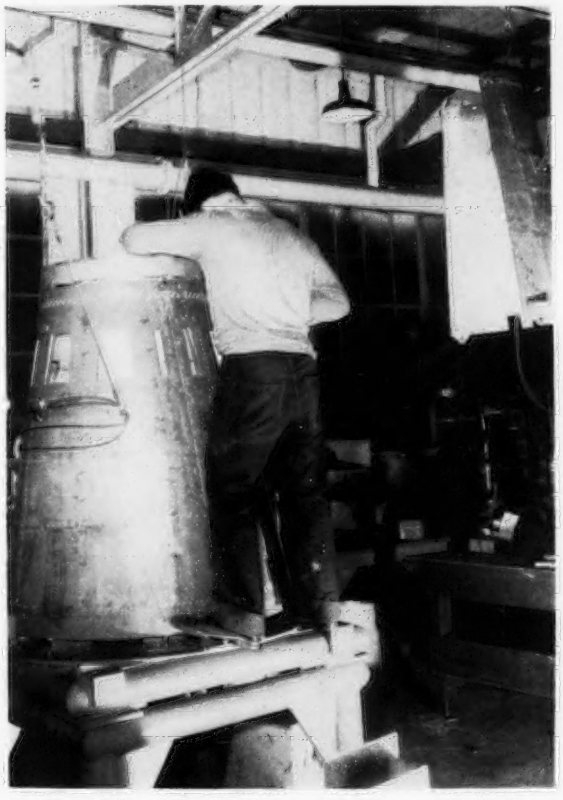
Draw dies and drop-hammer dies are also fabricated with epoxy facing and Kirksite cores. In the case of the drop-hammer dies, a resilient epoxy is used on the punch half to absorb the high impact loads and accommodate the part material thickness.

Phenolics and Polyesters

Successful plastic tooling for airframes is dependent upon the choice of the correct material for the correct job, epoxies are not masters

Initial stage in the buildup of a laminated glass cloth and epoxy resin drill basket.
Tool makers are shown locating drill bushings.

Precut layer of glass cloth is applied during the buildup of a laminated plastic drill basket. Workers wear protective gloves and aprons.



Drill jig basket is clamped on formed sheet metal parts and hole pattern drilled easily.

epoxies move in

of all jobs, phenolics and polyesters have considerable application.

Polyesters are the least expensive of the three and are used principally for glass-reinforced laminated tools where high dimensional accuracy is not required.

Phenolics are the middle of the road resins, not as expensive as epoxies, but not as good in physical properties either. They should be used only where resistance to impact is not required. Routing fixture bases, stretch form blocks, and press forms are typical applications.

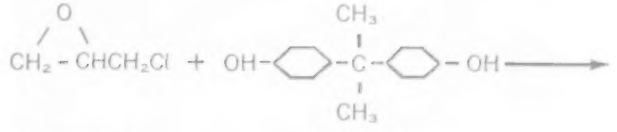
Foaming phenolics are sometimes used as core material to lighten large tools.

To effect full cure and optimum physical properties for phenolics an oven cure is required. With some sacrifice of physicals and an increase in subsequent shrinkage, room temperature cures may be used.

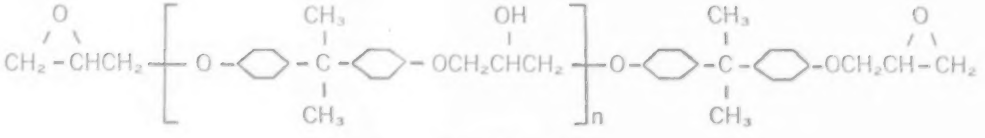
Cost Reductions With Plastic Tooling

No mention has been made thus far of the equipment used in the manufacture of plastic

• ABOUT THE EPOXY RESINS



Epichlorohydrin Bis-phenol A



Typical Uncured Epoxy Resin

The terms epoxy, epoxide, ethoxy, ethoxyline, and oxirane are all used in referring to a class of resins which contain the oxirane ring. In some quarters the family of resins is referred to as the epichlorohydrins, because the chemical compound epichlorohydrin is used as the base compound in fabricating the long chain resins.

The manufacture of most commercial epoxy resins takes as its basis the reaction of epichlorohydrin with a bi-functional hydroxyl containing compound. Typical of the bi-functional hydroxyl compounds is bis-phenol-A, a symmetrical inexpensive pure dihydric phenol (i.e., contains two OH groups).

Curing

Since the basic resins are fluid and thermoplastic, certain curing or hardening agents must be added to effect a cross-linking of the compounded epoxy resins. The exact chemistry of curing agents becomes quite involved and is still a highly secretive and competitive field. Generally, however, amines or organic anhydrides and acids are used as curing agents.

Use is made of the reactivity of the oxirane ring in cross-linking during the curing cycle. The (OH) groups in the chain are also reactive under certain types of curing. The wide spacing between the functional epoxy rings located at the ends of the long molecule assists in providing some flexibility to the cured resin.

During the cure, changes in volume are small because there are no volatiles given off, and because there is a high intermolecular association between the epoxy and hydroxyl groups of the uncured resin.

Reference: A. Cianciarulo, New Products Chemist, Ciba Co., Kimberton, Penna.

tools. Apart from resin mixing machines and layout tables little is needed other than cutting knives, brushes, safety latex gloves, and protective aprons for workers.

The labor required is predominantly semi-skilled, this releases highly skilled toolmakers for conventional metal tooling.

Safety In Storing and Handling

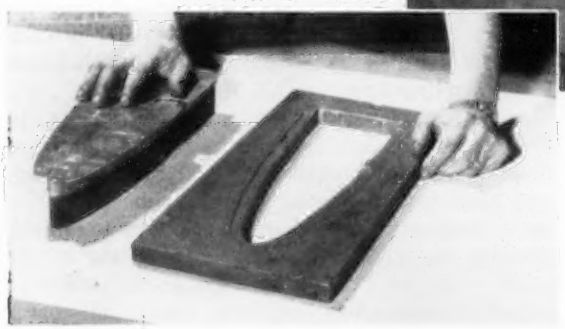
For maximum efficiency the plastic shop should be maintained at a temperature of 70-80°F. Higher temperatures reduce pot life of the resin, lower temperatures prolong room temperature cure unnecessarily.

TOOLING RESINS IN USE AT AVRO

Tooling	Resin	Hardener	Room Temp. Cure Time
Master model (filler material)	Auto-Air S.4. 10	6 per cent A16 Auto-Air	8 hr
Master model (rough coat)	Kish 417T	17 per cent 40A Kish	4 hr
Master model (finish coat)	Kish 418S	17 per cent 40A Kish	4 hr
Templates and drill baskets	Auto-Air L-100	17 per cent A15 Auto Air	24 hr
Drop hammer punches (resilient)	Kish 247 Kish 358	no hardener. 50-50 mixture of resins is self hardening	24 hr
Drop hanner dies (non-resilient)	Kish 312 (or)	17 per cent 40A Kish	4 hr
	Auto-Air C200	17 per cent A15 Auto-Air	4 hr

Laminated epoxy drill and trim jig is used to shape sheet metal part and accurately locate 86 holes that are drilled with a hand tool

Epoxy resin wiper die used in a Hydropress form block. Wiper die eliminates wrinkles which might occur during press forming.



plastic fuselage

honeycomb sandwich with laminated skins investigated for helicopters; increased strength, decreased cost are among advantages claimed

by **William Peck**, Research and Preliminary Design Group, Vertol Aircraft Corp.

Manufacturing helicopter fuselages entirely of glass reinforced plastic has been shown to be not only structurally feasible but to be superior in some respects to fuselages of conventional design.

As a result of studies conducted at Vertol Aircraft Corp., proposals were submitted to the defense department for incorporation of plastic honeycomb sections into several of its latest aircraft.

Distinct advantages are realized in bending strength; shear strength is about equal, and weight is equal to or slightly in excess of conventional aluminum alloy construction. Other advantages offered by a plastic honeycomb fuselage are:

- Reduced vibration, resulting from high inherent structural damping of the plastic
- Minimized use of strategic materials
- Decreased cost of fabrication
- Decreased radar reflectivity

The fuselage shell configuration studied was similar to the constant section of the H-21. Basic construction approach was to simultaneously cure and bond multi-layer glass reinforced plastic to a plastic honeycomb core to form open half or quarter fuselage shells. Final assembly of the shell pieces is effected by metallic fittings cured into the sandwich and by adhesive bonding.

Materials

The test panels fabricated varied in size from flat 5 x 5 in. sections to curved 5 x 8 ft sections. The most severe curvature being a 35 in. radius extended through a 90 deg arc.

Epon 828, an epoxy resin, was impregnated in Style 181 glass cloth for use as facing material of the sandwich fuselage shell test specimens.

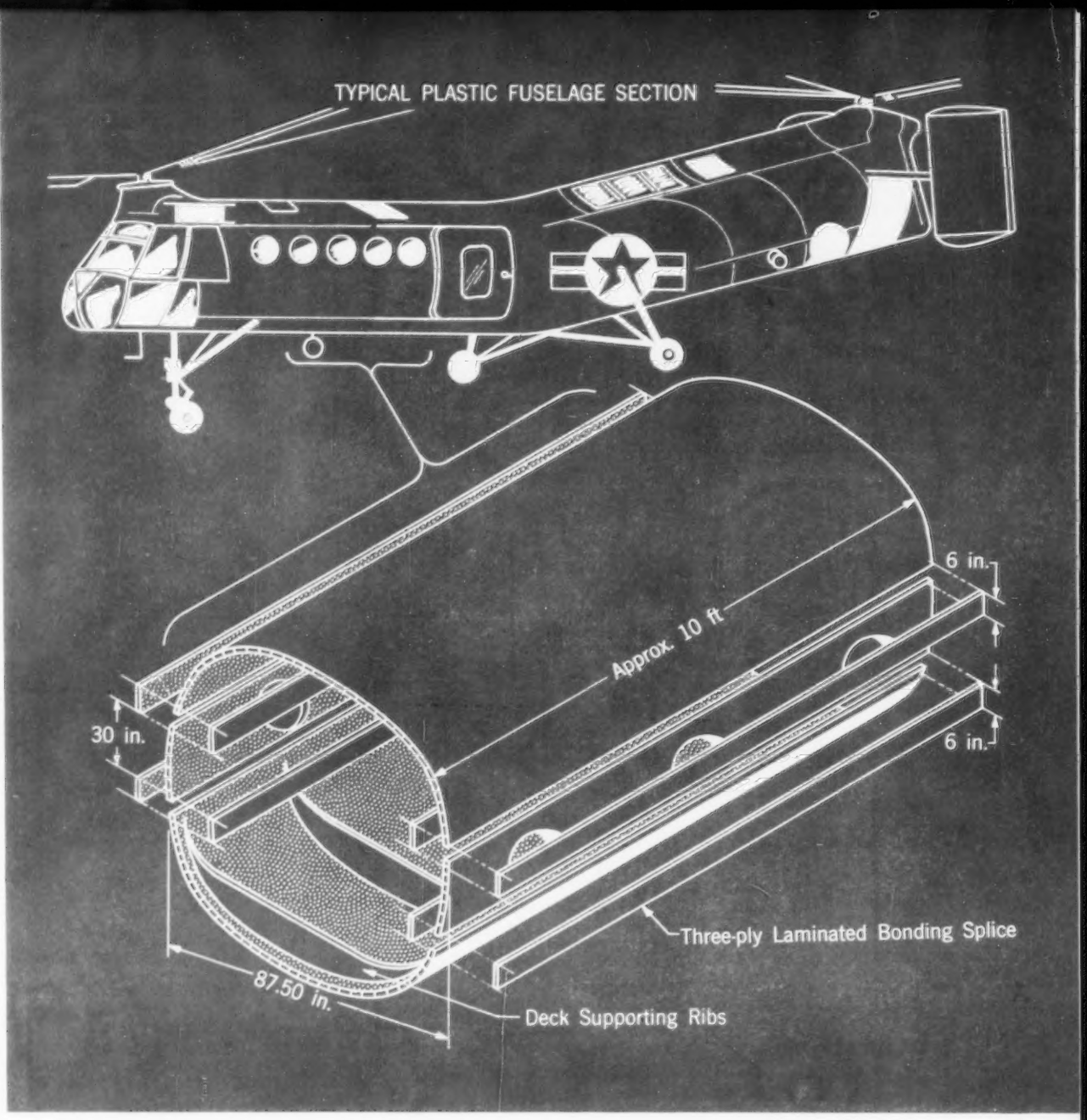
One inch phenolic honeycomb core with $^3/_8$ in. hexagonal cells was used to fill the sandwich. All primary skin-to-core bonds were effected with a nitrile phenolic adhesive, roller-coated on the core and cured under vacuum pressure at 350° F. Secondary bonds, which secured shell reinforcement members where effected by a room curing epoxy adhesive (Epon VI).

The resin impregnated glass cloth was allowed to partially polymerize, "B-Stage," prior to placing it in the layup. This was to minimize resin flow from the faces into the core during the final cure.

Shell Fabrication

Curved specimens were manufactured in a contoured female mold with appropriate vacuum outlets. Layup of the impregnated glass cloth was performed outside the mold. Two 0.012-in. aluminum liner sheets were spray coated with Lunn-Lease parting agent.

Three layers of impregnated glass cloth were placed in position on each of these aluminum sheets. One liner with the cloth layup in place was lifted into the mold. Next the adhesive coated honeycomb was placed in position in the mold. Finally, the second liner sheet was laid in the mold with the glass cloth against the adhesive coated honeycomb. The thin aluminum sheets



readily formed to the contour of the mold but were of sufficient thickness to prevent dimpling of the impregnated cloth into the core cells. They also facilitated removal of the specimen from the tool.

The entire assembly was covered with several layers of loosely woven dry glass cloth to insure adequate air flow in the subsequent application of vacuum.

The layup was then bagged, by clamping a loose polyvinyl alcohol sheet to the edges of the mold. The mold was placed in an electrically heated oven and a vacuum pump was attached to the evacuation ports on the mold. A pressure of 12.5 to 14 psi was maintained during the cure cycle (2 hours at 350°F). The specimen was not removed from the mold until it had cooled to room temperature.

It should be noted that honeycomb billets were not available in sufficient size to allow the

plastic fuselage

continued

core to be fabricated in one piece. The honeycomb was spliced. A simple, unbonded lap joint was produced by pressing the last line of hexagonal cells in one billet into the first line of hexagonal cells of the mating billet. No attempt was made to bond this joint.

Tests showed the lap joint to be as strong or stronger than the basic core, since core shear failures were experienced in the unspliced core but never at the joint. Shear forces were transferred from one block to the other through the faces and through the liquid adhesive roller-coated onto the honeycomb after the splicing operation.

Reinforcing frame members were similarly fabricated on flat fixtures and machined to shape on a band saw.

Strength Data

The specimens fabricated were tested in bending, compression, shear, and combined loadings. The basic information gained in testing approximately 115 specimens is condensed in Table I. Applying this data to the H-21 fuselage,

TABLE I

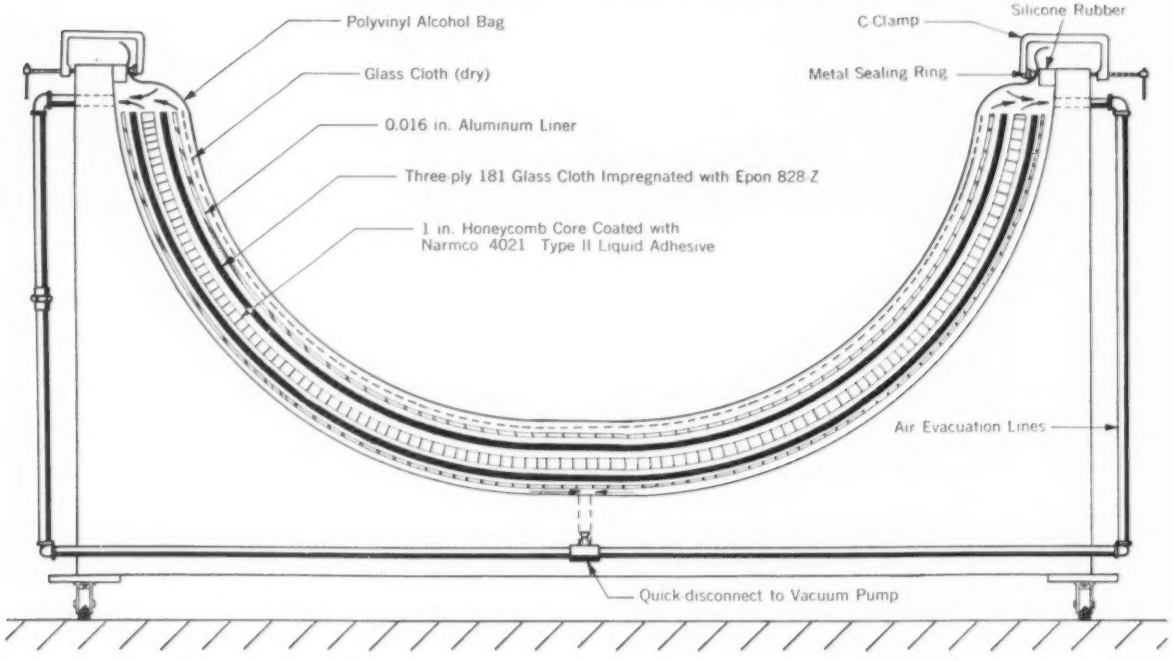
STRENGTH DATA FROM TESTING 115 SANDWICH SPECIMENS

Ultimate Tensile Strength (UTS)	50,000 psi
Tension Modulus	3.5×10^6 psi
Flexural Modulus	3.1×10^6 psi
Ultimate Shear	7,900 psi
Shear Modulus	5.7×10^5 psi

Three specimen shell sections—one showing stiffener ribs bonded by secondary process.

Cross section of contoured female mold shows constituents of layup.

TOOL AND LAY-UP FOR FABRICATING TYPICAL SHELL


Polyvinyl Alcohol Bag
Glass Cloth (dry)
0.016 in. Aluminum Liner
Three-ply 181 Glass Cloth Impregnated with Epon 828-Z
1 in. Honeycomb Core Coated with Narmco 4021 Type II Liquid Adhesive
C Clamp
Silicone Rubber
Metal Sealing Ring
Air Evacuation Lines
Quick disconnect to Vacuum Pump

it may be stated that an all plastic fuselage would be of the same rigidity in bending and torsion as a conventional skin and longer-on fuselage of aluminum alloy. The plastic fuselage would weigh approximately 5 per cent more, have approximately 50 per cent more strength in bending, and equal strength in shear. Fabrication costs could probably be decreased.

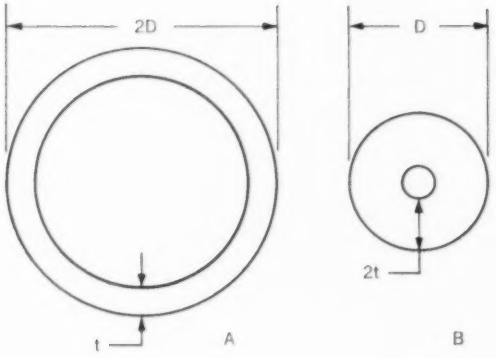
Since this was an evaluation test, there is little doubt that refinements in design, and further study in design of structural plastics could yield much stronger and lighter-weight fuselages.

Weight Breakdown

A typical one square foot section of the plastic honeycomb shell would weigh about 0.807 lb. The breakdown being: honeycomb core 0.225 lb; core to skin adhesive 0.035 lb; impregnated glass cloth 0.546 lb.

The greatest potential for variations in weight was found to be the manner in which the liquid adhesive was applied to the core material. The weight given above, or 0.0175 lb per sq in. per face, was found to be adequate, but was not established as minimal.

• BASIC DESIGN DATA



The text that follows is to correlate some of the basic considerations in designing a fuselage to the data compiled in testing the vacuum-formed, three-ply epoxy impregnated, Style 181, honeycomb structures.

It is essential that the stress analyst has the means of calculating the strength of various components as well as having at his disposal data on the basic properties of the materials of construction.

The important properties for consideration in helicopter fuselage design are rigidity and strength. Rigidity is generally not influenced by size or shape of a component; that is, a rigid material will make a component of equal rigidity. Strength, however, is a function of the type of loading and the configuration of the component.

As an example, in a monocoque shell similar to that considered in the plastic fuselage study, it is possible to increase the strength by: (1) increasing the diameter of the shell, (2) decreasing the wall thickness.

The illustration shows two tubes, one thin-walled, the other thick-walled. Both are of the same material, length, and weight. The diameter of (A) however is twice that of (B), and the wall thickness of (A) is half that of (B). It may be stated generally that the tube (A) with twice the diameter and half the wall thickness will carry four times the load of (B) in compression. It is also four times as rigid in bending, and torsion.

Rigidity as distinguished from strength is of extreme importance. The rigidity of a fuselage is a controlling factor in the resultant vibration and thus controls the safety of the aircraft.

The following data and suggested formulae provide a means of calculating the strength of a bonded honeycomb sandwich structure of the type proposed for the plastic fuselage.

MODULUS OF RIGIDITY—G—

Measured values of G averaged 575,000 psi.

TENSION OR COMPRESSION MODULUS—E—

Measured values of E averaged 3,500,000 psi.

FLEXURE MODULUS—Ef—

Measured values of Ef average 3,100,000 psi.

TENSILE STRENGTH—Ft—

Measured values of Ft average 35,000 psi.

COMPRESSIVE STRENGTH—Fc—

The critical compressive failure mode for this sandwich is that generally termed face wrinkling. The measured values of face wrinkling strength for this sandwich averaged 29,000 psi. This is slightly higher than predicted by the empirical formula

$$F_c = \sqrt[3]{(E_{face} \times E_{core} \times G_{core})^2}$$

proposed by Bijlaard in the *Journal of the Aeronautical Sciences*, May 1951.

COLUMN COMPRESSIVE STRENGTH—Fcc—

The column compressive strength is a function of length and curvature of the component. Good agreement of measured and theoretical data on flat columnar components is achieved by using the Johnson Parabolic Column Equation, substituting the face wrinkling stress for the compressive strength at zero column length. Columns of curved cross section which were tested did not exhibit agreement between experimental and theoretical data. This may be due to the edge effects which create local weak spots where failures may start.

The large 5 x 8 ft specimens tested failed at a compressive stress of 18,000 psi. Predicted failing stress for these specimens was 24,000 psi. This prediction is based on modification of standard equations for columns of curved cross sections suggested by Timoshenko in his text *Theory of Plates and Shells.*

spin forming

materials, techniques, and applications for this growing 'chipless machining' process

The ancient potters did it with clay; modern missile manufacturers do it with high strength metal alloys. In the first instance, it is an ancient art, in the latter it is a "new" concept in machining that is destined to account for tremendous savings to missile manufacturers in the fabrication of airframe and engine components. The process is "spin forming," a type of "chipless machining."

As a result of the increased prominence of highly stressed circular, spherical, and conical shapes in missiles, as well as jet and rocket engines; chipless machining, or machining by moving rather than removing metal, may have found the industry that will give it new growth impetus.

Variously identified by the names Hydrospin, Floturn, Rollform, Roll Flow, and Shearform, the "spin forming" process offers economical advantages by:

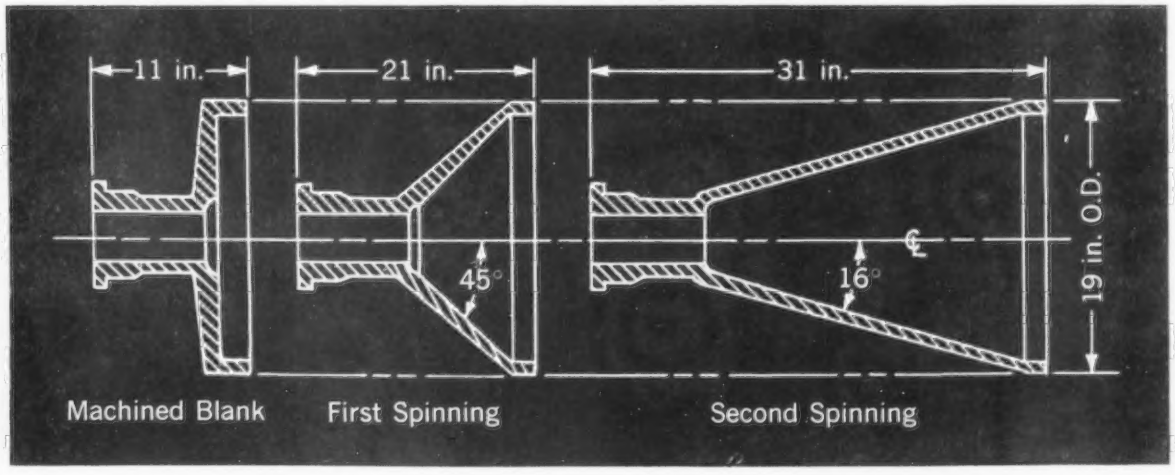
- Reducing machining time, since only one forming step is involved.
- Reducing tooling costs, since only one master mandrel is required.
- Reducing material waste by eliminating chips.
- Reducing finishing costs since smooth finish is imparted in the forming process.

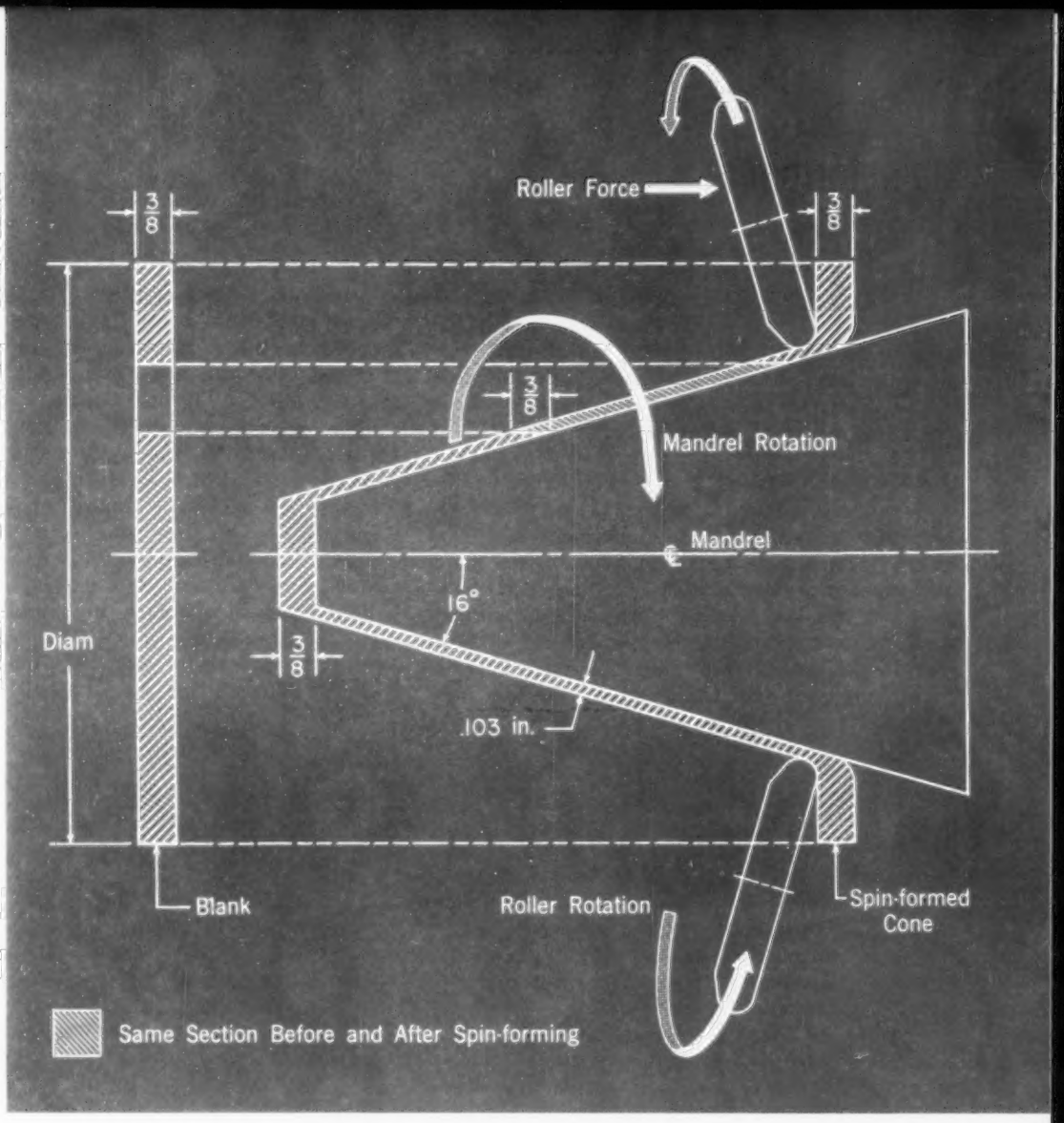
The Process

Hardware that is essentially sheet metal can be fabricated into intricate circular shapes with dimensional tolerances (± 0.002 inches) normally accomplished only in a combination of forging and multi-step machine tool cutting operations.

The process resembles hand spinning in the respect that the work piece is rotated while being formed over a mandrel. Heavy pressures applied through rollers are used to displace the metal from the sheet metal blank or preformed shape into the desired configuration.

Continued on page 42

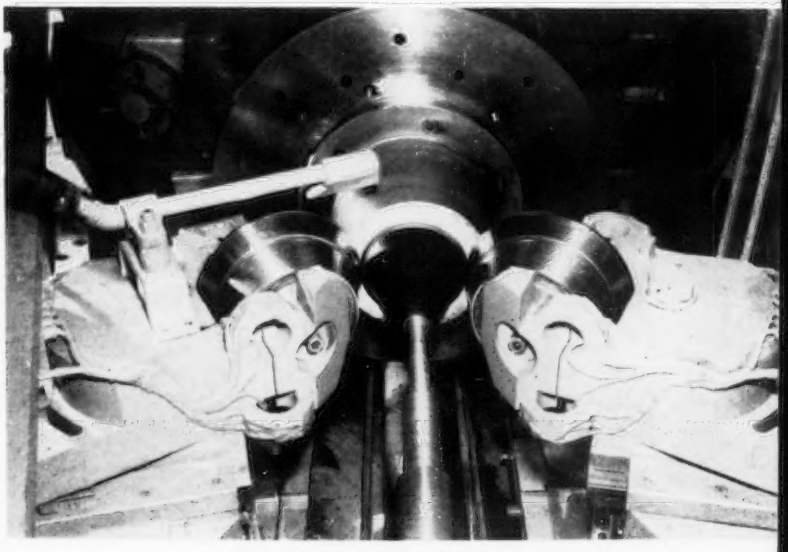




In "shear spinning" a flat blank is moved longitudinally over a cone shaped mandrel under the heavy compressive stress of rollers.

Stream of lubricant and coolant is applied where rollers contact mandrel. One liquid serves both purposes when wall reductions are not great.

Two mandrels are used when spin forming is done in stages. 100 lb of chips were eliminated in this job by changing to spinning methods.



spin forming

continued

Although the majority of parts can be formed by a single pass of the rollers, multiple passes, or stage forming, with intermediate annealing; can be accomplished where the final shape is intricate or where the material being spun has moderate or low ductility.

Metallurgical Changes

The spin forming process is essentially cold working (titanium, molybdenum, magnesium and beryllium are spun hot) and as such, the grain structure of the metal work piece is greatly elongated. The micro structure is severely deformed and oriented parallel to the spin formed surface. This results in tensile strength increases as high as 100 per cent over the unspun material; there is also a corresponding increase in yield strength. As might be expected, tensile elongation and bend ductility are simultaneously decreased, bend ductility in a lesser degree than tensile elongation.

Materials

For satisfactory spin forming, materials should possess a high degree of ductility and strength. However, some materials, whose ductility makes them unsuitable for drawing and machining by conventional methods, exhibit a higher order of formability in spin forming.

The high temperature and austenitic stainless steels have a capacity for plastic flow and a resistance to cracks and deformation that make them one of the best class of materials for spin forming. Some other high temperature alloys which have been spun successfully are Circiloy-Z, Monel, K-Monel, and Timken 16-25-6.

Most mild and high alloy steels are suitable; as carbon content increases the extent of possible rotary plastic deformation decreases. Ferritic structures are formed readily, whereas coarse iron carbide laminae are plastically formed into highly oriented grain structures in the finished part. The free carbide can be put into a workable condition for some part configurations by spheroidizing before the spinning process.

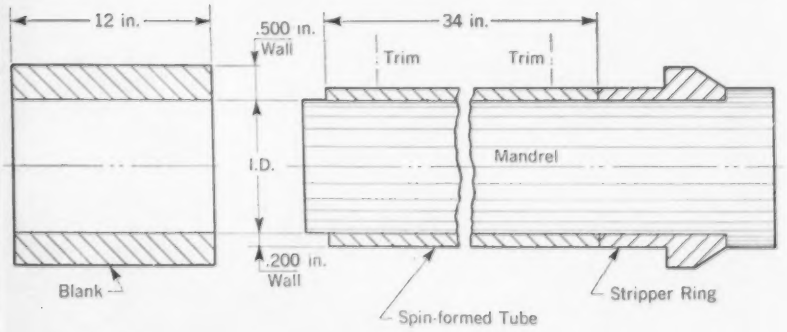
Other steels which have been formed by spinning are series 200, 300 and 400 stainless steels. Micro structures of various steels before and after spin forming are shown in accompanying photographs.

Most wrought aluminum alloys spin well. Processes presently being evaluated are the spinning of aluminum after various stages of heat treatment, and then allowing the material to come to full hardness by aging after spinning.

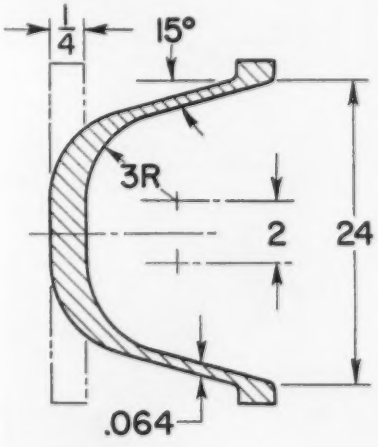
The comparatively low ductility at room temperature of titanium, magnesium, and their respective alloys necessitates application of heat during spin forming. The optimum forming range for commercially pure titanium seems to be from 900 to 1000° F., while for the A110-AT alloy the temperature range rises from 1200 to 1400° F.

HK-31 magnesium alloy (3 per cent thor-

The "tube spinning" principle is used in making thin-walled tubing from heavy rings.



"Contour spinning" is used when the final shape desired is curvilinear.



ium and 0.75 per cent zirconium) reaches its ductile transition range at 650 to 750°F. However, even at these temperatures the alloy has been spun with only marginal success.

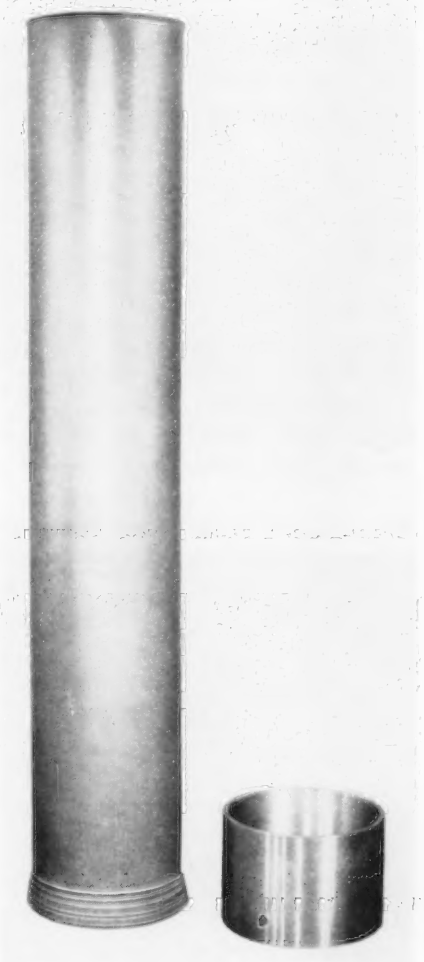
High temperature alloys (N-155, 19-9DL, 19-9 DX and Inconel) which strain harden rapidly and are difficult to work with conventional sheet metal processes, respond well to spin forming. Parts produced from these materials have good dimensional accuracy (±0.002 inches) even when material thickness is reduced as much as 75 per cent during spinning.

The loss of elongation and bend ductility after high percentages of wall reduction is so pronounced in some cases of the high temperature alloys that a recrystallization annealing operation is necessary, depending on the end use of the spin formed part. This is performed with excellent results by treating at 1850°F for 30 minutes and then air cooling. The degree of cold working usually results in a refined grain size in the annealed material.

Welds and Cast Material

Welding is often employed to produce preforms for spin forming; this welding must be high quality and absolutely sound. Any slag inclusion

Continued on next page



Variety of parts made by the three spin forming methods.

4130 steel blank 10 in. long, spun to 58 in. tube .065 in. thick.

Piece with 30 deg incl. angle contour spun from steel blank.

spin forming

continued

Although the majority of parts can be formed by a single pass of the rollers, multiple passes, or stage forming, with intermediate annealing; can be accomplished where the final shape is intricate or where the material being spun has moderate or low ductility.

Metallurgical Changes

The spin forming process is essentially cold working (titanium, molybdenum, magnesium and beryllium are spun hot) and as such, the grain structure of the metal work piece is greatly elongated. The micro structure is severely deformed and oriented parallel to the spin formed surface. This results in tensile strength increases as high as 100 per cent over the unspun material; there is also a corresponding increase in yield strength. As might be expected, tensile elongation and bend ductility are simultaneously decreased, bend ductility in a lesser degree than tensile elongation.

Materials

For satisfactory spin forming, materials should possess a high degree of ductility and strength. However, some materials, whose ductility makes them unsuitable for drawing and machining by conventional methods, exhibit a higher order of formability in spin forming.

The high temperature and austenitic stainless steels have a capacity for plastic flow and a resistance to cracks and deformation that make them one of the best class of materials for spin forming. Some other high temperature alloys which have been spun successfully are Circiloy-Z, Monel, K-Monel, and Timken 16-25-6.

Most mild and high alloy steels are suitable; as carbon content increases the extent of possible rotary plastic deformation decreases. Ferritic structures are formed readily, whereas coarse iron carbide laminae are plastically formed into highly oriented grain structures in the finished part. The free carbide can be put into a workable condition for some part configurations by spheroidizing before the spinning process.

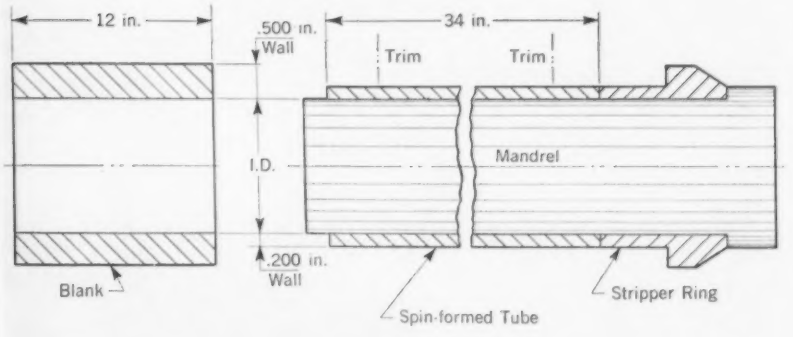
Other steels which have been formed by spinning are series 200, 300 and 400 stainless steels. Micro structures of various steels before and after spin forming are shown in accompanying photographs.

Most wrought aluminum alloys spin well. Processes presently being evaluated are the spinning of aluminum after various stages of heat treatment, and then allowing the material to come to full hardness by aging after spinning.

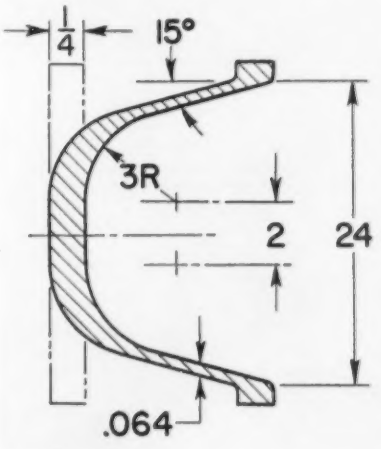
The comparatively low ductility at room temperature of titanium, magnesium, and their respective alloys necessitates application of heat during spin forming. The optimum forming range for commercially pure titanium seems to be from 900 to 1000° F., while for the A110-AT alloy the temperature range rises from 1200 to 1400° F.

HK-31 magnesium alloy (3 per cent thor-

The "tube spinning" principle is used in making thin-walled tubing from heavy rings.



"Contour spinning" is used when the final shape desired is curvilinear.



ium and 0.75 per cent zirconium) reaches its ductile transition range at 650 to 750°F. However, even at these temperatures the alloy has been spun with only marginal success.

High temperature alloys (N-155, 19-9DL, 19-9 DX and Inconel) which strain harden rapidly and are difficult to work with conventional sheet metal processes, respond well to spin forming. Parts produced from these materials have good dimensional accuracy (±0.002 inches) even when material thickness is reduced as much as 75 per cent during spinning.

The loss of elongation and bend ductility after high percentages of wall reduction is so pronounced in some cases of the high temperature alloys that a recrystallization annealing operation is necessary, depending on the end use of the spin formed part. This is performed with excellent results by treating at 1850°F for 30 minutes and then air cooling. The degree of cold working usually results in a refined grain size in the annealed material.

Welds and Cast Material

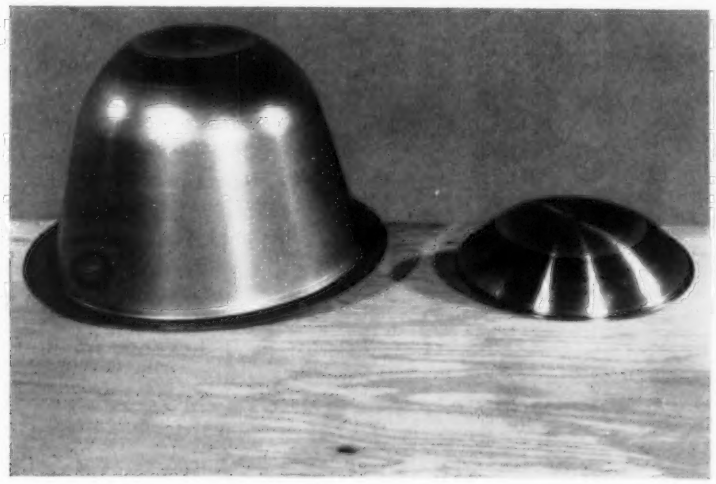
Welding is often employed to produce preforms for spin forming; this welding must be high quality and absolutely sound. Any slag inclusion

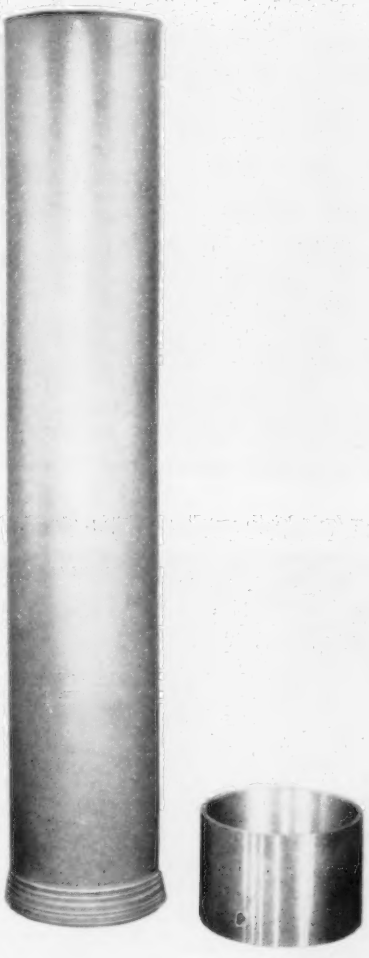
Continued on next page

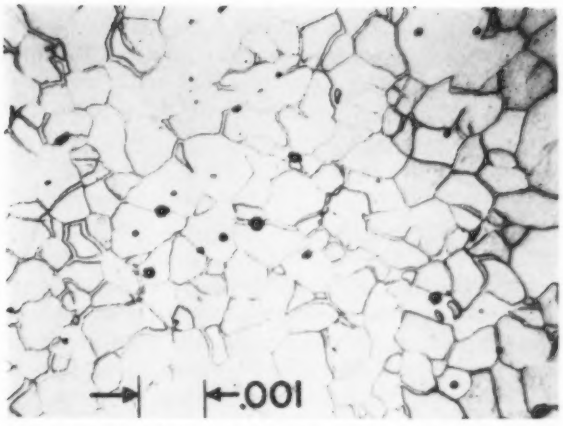
Variety of parts made by the three spin forming methods.

4130 steel blank 10 in. long, spun to 58 in. tube .065 in. thick.

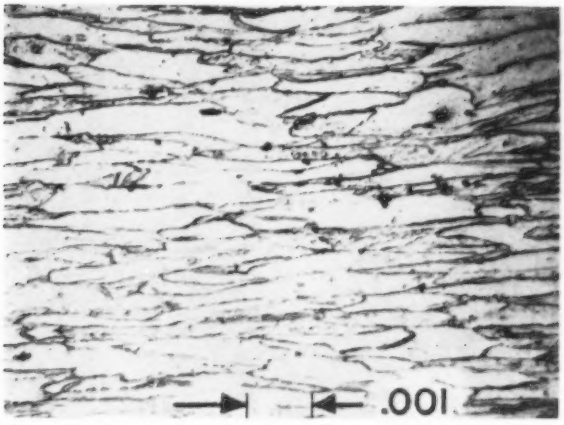
Piece with 30 deg incl. angle contour spun from steel blank.





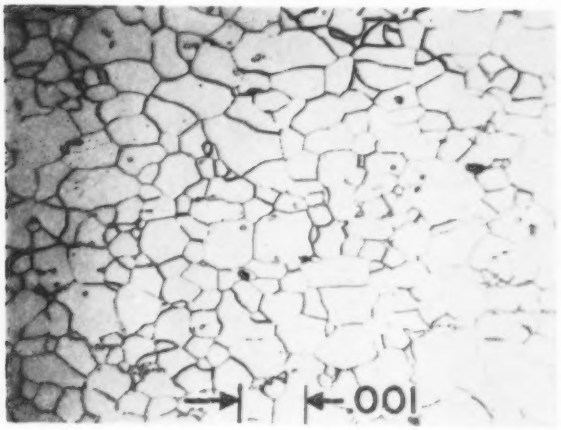


Micro-structure of annealed low carbon steel (normal).



Elongated grain structure after 70 percent wall reduction

Grain structure restored by heat treatment (1200°F, 1 hr).



or void will cause failure during spinning.

A weld is constituted of cast material which may not initially tolerate as severe a reduction as wrought material. It is best to plan spin forming operations with this in mind.

Centrifugally cast rings of AISI 4130 and 304 stainless have been spun into tubes with wall reduction thicknesses up to 80 per cent. Complete transition from cast to wrought grain structures has been achieved. Work with cast aluminum alloys has been successful to a lesser degree.

Types of Chipless Machining by Spinning

Spin forming may be divided into three categories: shear, tube, and contour spinning.

Shear spinning is used to produce conical parts from flat discs. Reduction in material wall thickness follows the Sine Law: Finished cone wall thickness is equal to flat blank thickness times the sine of one-half the included cone angle. An included cone angle of 30 deg is usually the minimum cone formed in one operation, since maximum reduction in thickness, of most materials is about 75 per cent. Cones of varying wall thickness, or less than a 30-deg included angle, require use of preformed blanks.

Tube spinning is essentially continuous point extrusion, and is often used to manufacture precision, seamless, thin-wall tubes from shorter, heavier-wall, ring-shaped preforms. In some cases mill-run lots of hot-rolled, pickled tubing have been successfully used as preforms. The I.D. remains constant, and the inside finish is generally improved. Tubes have been produced with 5 to 8 micro-inch finish on the I.D.

Contour spinning involves use of cross slide tracer control to permit spinning of curvilinear shapes. With this method, the principles of both tube and shear spinning are employed if desired.

In both shear and tube spinning, maximum reductions of material thickness depend on machine force capacity and material ductility. In tube spinning, multiple passes can produce a 90 per cent reduction, without intermediate annealing, in AISI 4130 steels, and 75 per cent reduction in AISI 52100 steels. In shear and tube spinning, preform wall thicknesses up to ¾ in. have been successfully spun to date. Machines with higher forces are on the drawing boards which should spin 1-in. thick stainless steels.

Spin Forming at Elevated Temperatures

The fact that both magnesium and titanium have lower ductility at room temperature than some other metals necessitates spinning at elevated temperatures.

Heat has most generally been applied by an oxy-fuel gas source. The Cincinnati Milling Machine Company equipment designated Flamatic, has been used successfully in applying heat to work pieces. Heat has also been applied to small parts with manual control with some greater difficulty.

Usually, no lubricant is necessary when spinning at elevated temperatures; however, at lower temperatures, lubricant and coolant are used.

Lubricant—Coolants—Feed Rates

The heat generated during cold spinning is high enough to be detrimental; it must be removed rapidly by a coolant. When roller pressures are low, one substance may serve as both the lubricating and cooling medium. When heavy blanks are spun, however, separate cooling and lubricating media are necessary.

A few of the coolants that have been used successfully are ethylene glycol, or water miscible substances like Cimcool, which possesses high heat absorbtivity and extreme pressure lubricant qualities.

Collodial zinc, molybdenum sulfide paste, and a commercial substance called Lubri Plate 630-A have demonstrated an ability to provide adequate lubrication to prevent galling at roller pressures up to 400,000 psi.

Feed rates are dependent on material composition, thickness and size; roller design and pressure. Feed rates range from between ½ to 52 in. per min, but production operations are usually between 4 and 26 in. per min.

PHYSICAL PROPERTIES OF MATERIALS IN SPIN FORMING

		ORIGINAL MATERIAL				SPIN FORMED MATERIAL						POST FORMED HEAT TREATED			
Material	Preformed Condition	Hardness Rockwell	Per Cent E in 2 in.	YS x 10^{-3}	UTS x 10^{-3}	Side Angle	Per Cent Reduction	Hardness Rockwell	YS x 10^{-3}	UTS x 10^{-3}	Per Cent E in 2 in.	Hardness Rockwell	YS x 10^{-3}	UTS x 10^{-3}	Per Cent E in 2 in.
N-155 (T)	Annealed	C-16	43	57	116	19°	68	C-47	216	219	2.7	—	—	119	36
N-155 (P)		—	—	—	—	19°	68	C-47	—	214	2.7	—	—	—	—
19-9 DX (P)	Stress Relieved	B-94	32	66	111.2	19°	68	C-43	—	200	0.66	—	—	—	—
19-9 DX (T)	At 1200° F	—	—	—	—	19°	68	C-43	—	192	3.0	—	—	—	—
Inconel (P)	Soln. Treated	B-88	45	40	90.0	19°	68	C-40	—	100	3.0	F-95	42.0	80.0	32.0
Inconel (T)		—	—	—	—	19°	68	C-40	—	150	3.5	—	43.0	86.0	42.0
Low Carbon Steel (T)	Cold Finished	B-79	24	54.0	72.0	25°	58	B-87	75.0	81.5	7.5	—	—	—	—
A-70 Titanium (T)	Annealed	B-90	23	80.0	90.0	20°	65	B-102	93.6	110.8	14.4	B-97	80.8	97.4	23
A-70 Titanium (P)		—	—	—	—	20°	65	B-101	101.1	115.0	9.2	B-97	80.0	97.4	16.5
A110-AT Titanium (T)	Annealed	C-33	18	120	125	21°	63.6	B-108	140.6	150.0	5.0	B-103	114.5	129.0	9.5
A110-AT Titanium (P)		—	—	—	—	21°	63.6	B-108	137.7	150.0	6.0	B-103	123.3	135.7	8.5
2024-T4 Aluminum (T)	Annealed	F-40	—	11.0	27.0	25°	58	F-75	—	—	—	—	42.9	65.3	15.9
2024-T4 Aluminum (P)		F-42	—	11.0	27.0	25°	58	F-77	—	—	—	—	43.8	64.7	14.0
1100 Aluminum (T)	Annealed	—	35	5.0	13.0	25°	53	E-67.5	28.0	30.3	6.0	—	—	—	—
1100 Aluminum (P)		—	—	—	—	25°	58	E-68	29.5	30.9	5.5	—	—	—	—
HK-31 Magnesium (T)	H-24	E-67	11.5	29.0	37.0	35°	43	E-63	16.0	—	9.0	B-67	21.4	36.2	10.5
HK-31 Magnesium (P)	Cold Finished	—	—	—	—	35°	43	E-62	33.9	35.3	3.0	B-67	22.8	36.6	8.3
C. P. Molybdenum (T)	Stress Relieved	C-22	13	122.9	124.7	15°	75	C-33	112.0	148.0	3.0	—	—	—	—
C. P. Molybdenum (P)		—	19	105.5	109.9	15°	75	C-33	128.0	150.0	3.0	—	—	—	—

If you sell the aircraft and missiles industry...

. . . edited specifically for men responsible for design, engineering, production and procurement in the aviation manufacturing industry. With a carefully selected circulation of more than 15,000, AMM will carry your advertising directly to the people you want to reach — the key buying influences in plants manufacturing airplanes, missiles, power plants and components — *and to these people alone!* No other publication in the field offers you such efficient use of advertising dollars to help increase your sales to manufacturers in this multibillion-dollar market.

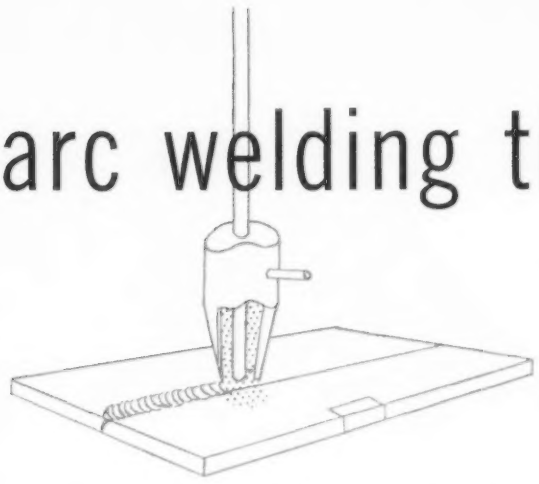
Aircraft and Missiles Manufacturing is published monthly by Chilton Company — a company with the resources and experience needed to make each of 16 trade and industrial publications outstanding in its field. In keeping with Chilton policy, the staff of Aircraft and Missiles Manufacturing devotes full time to the publication, striving for editorial excellence and quality circulation. In achieving both, it is earning the confidence of readers and advertisers alike.

Chilton
COMPANY

Chestnut and 56th Streets • Philadelphia 39, Pennsylvania

Publisher of: Department Store Economist • The Iron Age • Hardware Age • The Spectator • Automotive Industries • Boot and Shoe Recorder Commercial Car Journal • Butane-Propane News • Electronic Industries • Jewelers' Circular-Keystone • Motor Age • Gas • Hardware World Optical Journal & Review of Optometry • Distribution Age • Aircraft and Missiles Manufacturing • Business, Technical and Educational Books

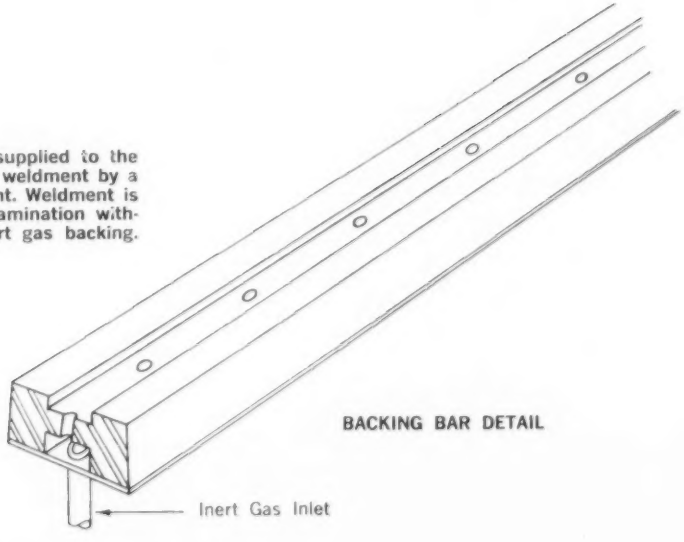
arc welding titanium



proper cleaning and shielding are keys to consistently good weldments

by **Andrew Eshman**, manager of service engineering
Thomas Janus, service engineer
Mallory Sharon Titanium Corp.

Inert gas shielding is supplied to the bottom side of the weldment by a backing bar arrangement. Weldment is susceptible to contamination without inert gas backing.



Titanium weldments with tensile and bend ductility properties equal to those of the base metal can be produced consistently if the several problems of titanium welding are understood and handled intelligently.

Some of the metallurgical facts about titanium which have the greatest effect on weldments are: Titanium's susceptibility to embrittlement by oxygen, hydrogen, and nitrogen; titanium's high reactivity and its tendency to combine with nitrogen, oxygen, and all known refactories at elevated temperatures.

The methods of coping with these problems are:

- Protection of both the face and the back of the joints from contamination during welding.
- Protection of weldment against atmospheric gases by using an inert gas shield.
- Thorough degreasing, descaling, and chemical pickling all parts to be welded.

Both tungsten arc and consumable metal arc methods have been used successfully on thin sheets, heavy plates, and forgings. However, each method has demonstrated certain advantages over the other in specialized cases.

Joint Design

Joint designs for inert gas shielded arc welds in titanium are similar to those for stain-

less steel. In butt welding thin sheet, squarebutt joints with practically no root opening are preferred. These weldments are made without the use of filler metals. When the sheets exceed about 0.06 in. thickness, a root opening or single vee-joint design is used to insure complete penetration; filler metals are needed. For heavy sections, single and double-vee butt joints are made. For corner weldments both open and closed joint designs are used. The number of welds coming together at any one point should be minimized. When filler is used, a joint clearance of ½ thickness to 1 thickness is recommended for simple butt joints in thicknesses up to 0.125 in.

Edge and Surface Preparation

Because of the extreme chemical reactivity of molten titanium, edge and surface preparation before welding are important to controlling contamination and porosity in the weldments.

In order to minimize contamination of the weldments, the edges of the joints and adjacent surfaces must be free of scale and other foreign matter. Material received from the mill is generally in the scale-free condition and requires only degreasing prior to welding. Material which has been hot formed or annealed has surface scale. Mechanical cleaning (sand blasting, grit blasting, or machining) or molten salt bath descaling in conjunction with pickling are necessary to prepare such material for welding. Pickling baths are of nitric-hydroflouric acid composition: 25 per cent HNO_3 and 2 per cent HF.

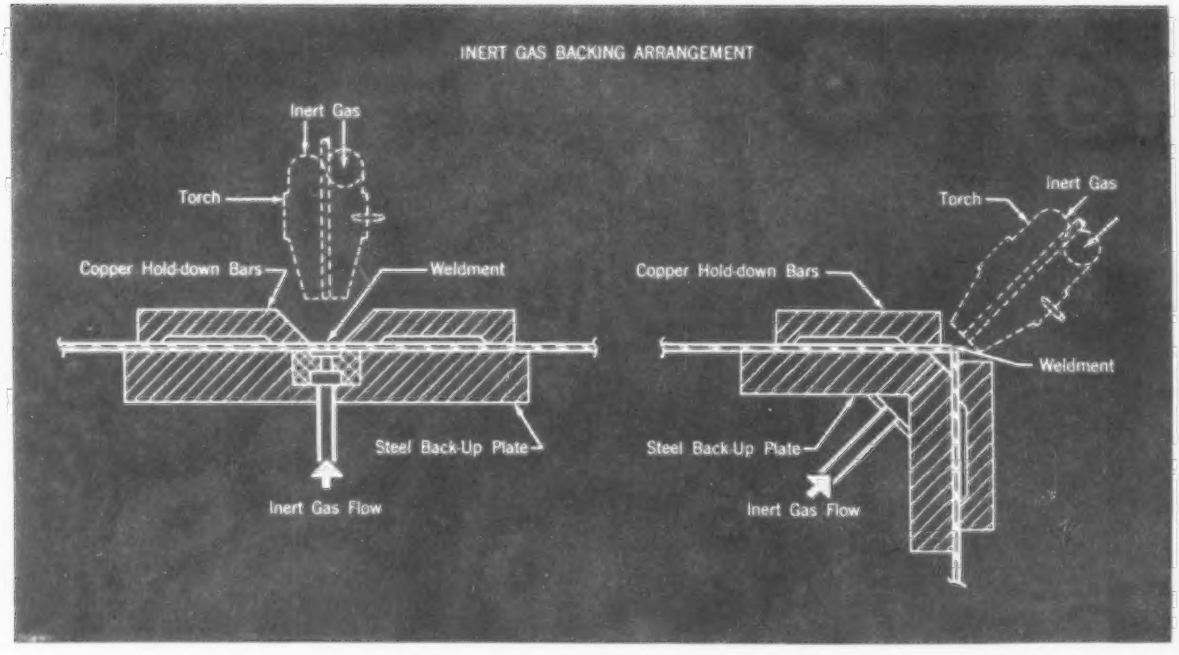
After the cleaning, special procedures are used to minimize porosity in the weldments. While the exact cause of weldment porosity is not clearly understood, recommended procedures for reducing porosity are: draw filing, abrading, and wire brushing the joint edges and adjacent surfaces. The joint edges may be degreased with acetone immediately before welding.

Welding Conditions

It is generally necessary to establish proper welding conditions using test specimens before welding assemblies.

With the tungsten electrode, weldments are made both with and without filler metal. Weldments made without filler metals are easier to shield. Filler metal may be fed by machine, preplaced in the joint, or fed manually. When filler metal is fed by hand, extreme care must be maintained to keep the hot end of the filler wire shielded from air.

Direct current straight polarity (electrode negative) is used with the tungsten electrode. Arc voltages range from less than 7 to more than 25 v; welding currents from less than 50 to more than 300 amp; and travel speeds from less than 5 to more than 30 ipm. Welding currents and



arc-welding titanium

continued

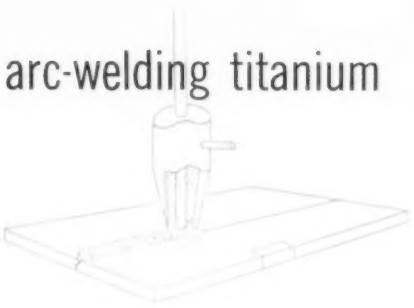


TABLE I

BACKING BAR GROOVE AND HOLD-DOWN SPACING FOR AUTOMATIC INERT ARC WELDING OF EQUAL GAUGES OF TITANIUM

Material Thickness, inch	Groove		Hold-Down Spacing, inch
	Width, inch	Depth, inch	
0.020–0.032	3/16	3/64	1/4
0.032–0.040	1/4	3/64	5/16
0.040–0.064	3/8	3/64	1/16
0.060–0.072	7/16	1/16	9/16

speeds have more effect on penetration than other variables.

With the consumable electrode, direct current reverse polarity (electrode positive) provides better metal transfer, greater arc stability, and less spatter than either direct current straight polarity or alternating current. Arc voltages range from 25 to 35 v and high current densities are required. Welding currents in the range of 300 amp are required for 1/16 in. diameter filler wire. Welding speeds range from less than 20 to more than 40 ipm.

Equipment

The equipment for welding titanium is essentially the same as for stainless steel: conventional welding heads, manual or automatic, using either tungsten or consumable electrodes, the tungsten electrode, direct current machines with straight polarity are preferred. With the consumable electrode, direct current equipment with reverse polarity is used.

ELECTRODES may be tungsten or consumable depending on the thickness of the metal to be welded. The tungsten electrode is used for sheet metal assemblies because it requires lower current densities and allows better control of weld penetration than consumable electrode welding. Consumable electrode welding is preferred for welding heavy sections, because it provides higher deposition rate and requires fewer weld passes than tungsten arc welding.

INERT GASES for shielding the weldments are helium, argon, and mixtures of the two. The purity of ordinary welding grade gases is satisfactory. Faster welding speeds and greater penetration can be achieved when using helium, however argon is used to a greater extent than helium, because it allows lower gas flow rates for comparable coverage, easier control of penetra-

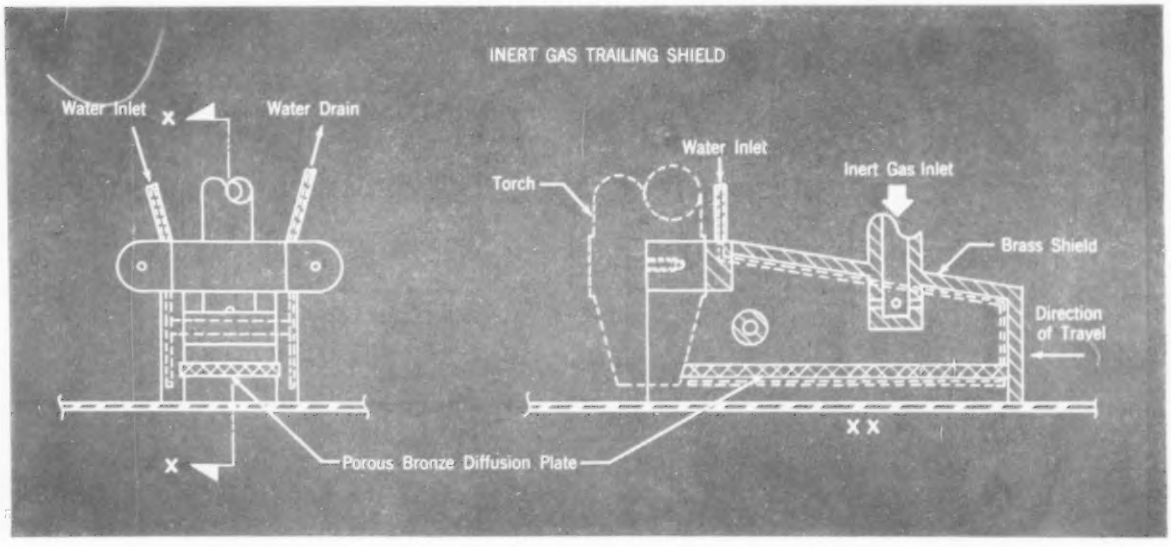


TABLE II

MINIMUM BEND RADII OF TITANIUM WELDMENTS

Material	Minimum Bend Radius, TR
MST 70 (commercially pure titanium)	3-4
MST 5A1-2Sn alloy	4-5
MST 821 alloy	5-6
MST 6A1-4V alloy	10-12*

* Ductility can be improved by the use of special filler metals and postweld annealing operations.

tion in welding thin sheet, and better metal transfer with the consumable electrode. Mixtures of the two gases are used most frequently in the consumable electrode process. Gas flow requirements will vary with torch cup size, material thickness, welding speed, current, and back-up for the specific setup.

FILLER METALS are usually commercially pure titanium or titanium alloys for manual or automatic arc welding.

Shielding

Adequate shielding is the most important consideration in the joining of titanium by welding.

WELDING CHAMBERS filled with inert gas offer the following advantages (1) elimination of elaborate jigs and fixtures which are sometimes necessary to obtain adequate shielding when complex shapes are welded in air and (2) attainment of more uniform shielding for manual weldments than can be obtained in air.

Inert gas filler welding chambers vary in size and shapes. In some, the entire assembly to be welded is placed inside the chamber, while in others, part of the assembly is sealed off. Ideally, a chamber which can be partially evacuated before back-filling with inert gas affords the best protection. When chambers cannot be evacuated they should be purged with the inert gas for sufficient time to insure the elimination of air and other gaseous contaminants. A common practice is to strike an arc on titanium scrap so the molten metal will "getter" or absorb any remaining contaminants before welding is begun.

OPEN AIR WELDING necessitates that backing bars be incorporated into welding fixtures to obtain the necessary shielding of the weldment from atmospheric gases.

Generally, the backing bar grooves vary with the thickness of the metal being joined. The grooves are designed to allow complete penetration and root fusion without excessive "drop through." Recommended groove dimensions for different thicknesses of sheet are listed in Table I. The amount of inert gas supplied through the backing bars ranges from less than 5 to over 30 cu ft per hr. The minimum gas flow rate that will provide reliable shielding is prefered.

When weldments are made in the thin sheet at relatively slow welding speeds, the inert gas flowing from the welding torch sometimes can provide adequate shielding. This is accomplished by the use of larger gas nozzles on the welding torch and proportionately higher gas flow rates than are required for other metals. For heavier sections or fast welding speeds, trailing speeds are required to protect the weldments as they cool. Copper hold down bars alongside the joint increase weldment cooling rates, act as baffles, and are beneficial in welding both with and without trailing shields. Recommended spacings for hold down bars are also listed in Table I.

Inspection

Bend tests have proved adequate for evaluating shielding conditions. If shielding conditions are good it is possible to bend the welded joint in commercially pure titanium around a mandrel with a radius of about three to four times the thickness of the sheet. If shielding conditions are not good, this ductility cannot be achieved. See Table II for minimum bend radii for various titanium materials.

The only non-destructive test for evaluating shielding is examination of the weldment surface. Surface appearance, however, is not always reliable and should be used with caution as a criterion for judging contamination during welding. Generally, surface examination is used in conjunction with bend tests for quality control on sample weldments. Weld beads with a polished silvery appearance indicate good shielding. If the surfaces are discolored, ranging from straw to blue, but still have a metallic luster, it is likely that the weldments are ductile. However, if the weldments have a heavy gray scale without metallic luster, contamination is usually excessive and such weldments are brittle. In chamber welding, an apparently clean weldment can be made that is contaminated enough to give poor bend ductility. This is the result of improper purging or leakage of air into the chamber during welding.

MATERIALS HANDLING EQUIPMENT

For the first time available in one big 636-page volume a book showing every machine and device made to move, elevate, convey, transfer, store, pack or transport solid and semi-liquid materials, also liquids when in containers. Over 2200 illustrations. Ideal reference book for executive, engineer, plant superintendent, salesman, instructor and student. $17.50

Over 600 PAGES **2200 DRAWINGS**

By

D. Oliphant Haynes

MANUAL OF AIR SURVIVAL

AIRCRAFT IN DISTRESS

Harley D. Kysor

Covers every type of aircraft emergency, assistance and distress operations, flying safety, aircraft emergency landing and "ditching" procedures, as well as first aid survival. Vital to all who own, fly, or travel by planes, this book provides practical, valuable, tested procedures. 432 pages, 59 illustrations, $6.00

Gordon B. Ashmead

AIRCRAFT PRODUCTION METHODS

A factual tour in words and pictures of all processes in aircraft manufacture. Partial list of contents: Master plaster pattern foundry – Sheet metal forming – The drop hammer – The draw process – The Guerin process – The Verson - Wheelon process – Heat and surface treatment – Optical and assembly tooling – etc. 293 pages, 324 illustrations, $7.50

Order today using this time-saving coupon

CHILTON BOOK DIVISION, Dept. AMM-1
56th and Chestnut Sts., Philadelphia 39, Penna.

Yes, send me on approval, with money-back guarantee:

.....copies MATERIALS HANDLING EQUIPMENT at $17.50 a copy

.....copies AIRCRAFT IN DISTRESS at $6.00 a copy

.....copies AIRCRAFT PRODUCTION METHODS at $7.50 a copy

I understand that I may examine the book(s) for 10 days and return without obligation if I am not satisfied.

☐ Bill me. ☐ Bill my company.

☐ Check here if remittance is sent with order, SAVING YOU the handling and postage charges.

NAME .....

COMPANY .....

STREET .....

CITY ..... ZONE ..... STATE .....

(Quantity discount schedule upon request.)

"The Business Press is our technical reference for present production and future progress"

says DONALD W. DOUGLAS, Chairman and President, DOUGLAS AIRCRAFT CO., Santa Monica, Cal.

"Swift are the wings of modern aviation. Swifter still is the pace that propels its technology. Know-how in this industry of flight," says Mr. Douglas, "is an ever-changing blueprint of tomorrow's needs today."

"The Business Press is our technical reference for present production and future progress. It is imperative reading for those who are bringing world leadership to America through jet propulsion, guided missiles and the like."

"We need Business Publications. We read the Business Press. We believe in Specialized Business Magazines. Their integrity, accuracy and instructional ability do much to lengthen and strengthen the wingspread of American aviation."

You will find that top men like Mr. Douglas, in *every* industry use business publications as a prime source of information about their own industry and their markets. Write for list of NBP publications — see how you can pin-point your market through the use of these technical, scientific, industrial, merchandising and marketing magazines.

NBP

NATIONAL BUSINESS PUBLICATIONS, INC.

1413 K Street, N. W., Washington 5, D. C. • STerling 3-7535

prevent grinding wheel burns,

by Martin Hartman, Consulting Engineer

Precision steel parts can be rendered worthless by invisible grinding wheel "burns."

Manufacturers and designers who insist on high quality are aware of the hidden detrimental effects which improper use of a grinding wheel may cause. They keep a constant vigil for imperfections in ground steel surfaces with an inexpensive inspection method: the nital etch.

In this method, a nitric acid solution selectively etches the ground part and produces color changes on the surface that a trained eye is able to identify with various stages of overheating and metallurgical transformation. Other more time consuming and expensive tests are often used to confirm the results of nital etch where part rejection would be expensive.

Defects are caused when the grinding wheel has locally overheated the steel to such an extent as to cause tempering or loss of hardness, and metallurgical deformation of the surface. The area of contact becomes so hot that it is often referred to as the "flame area." The resultant burns and cracks create fissures, reducing the tensile strength to the extent that the part may no longer take repeated loads.

Grinding cracks and burns may often be prevented by adequate attention to the following:

- The use of proper coolants.
- Care in selection of abrasive; size, type, and hardness.
- Proper peripheral speeds of the grinding wheel.

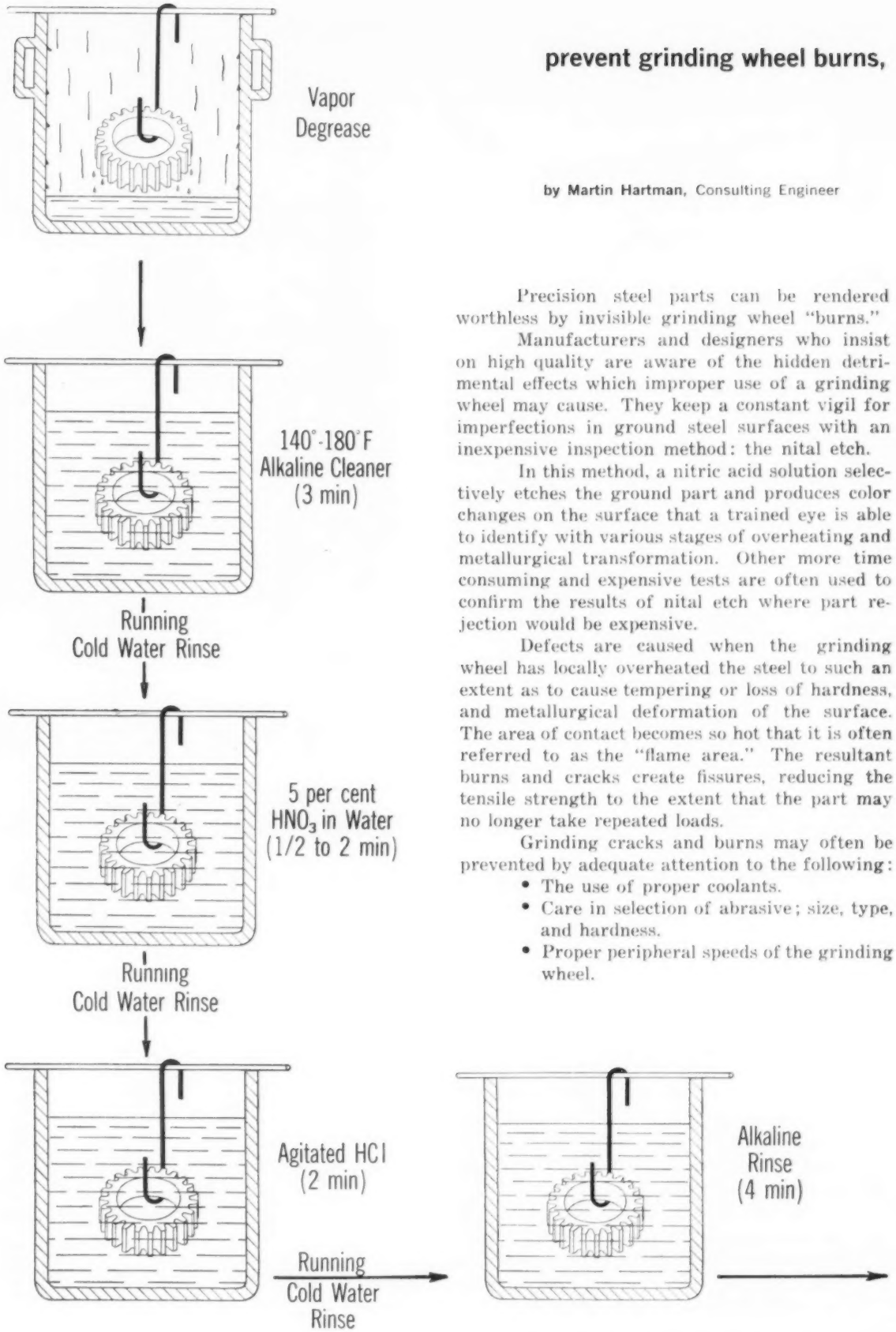

Vapor Degrease
140°-180°F Alkaline Cleaner (3 min)
Running Cold Water Rinse
5 per cent HNO_3 in Water (1/2 to 2 min)
Running Cold Water Rinse
Agitated HCl (2 min)
Running Cold Water Rinse
Alkaline Rinse (4 min)

Fig 1: NITAL ETCH DIP METHOD

but if they occur detect them with:

nital etch inspection

- Grinding wheel dressing with sharp high grade diamonds.

Chart No. 1 contains the grinding specifics found to give most satisfactory results.

The optimum situation is to prevent grinding burns; but if they occur they must be detected. Even with proper attention to the above items it is possible that invisible surface transformation may occur if the part has been improperly heat treated.

Detecting "Burns"

A common method for locating defects not readily visible to the naked eye is the nital etch. The exact method of use varies greatly among aircraft parts producers. However, for case hardened and through hardened, high carbon steels two methods seem to predominate. The procedure and data presented here are applicable to gears, bearings, and cylinders.

The two methods used in applying the nital etch are the dip and the swab methods. Each requires a special nitric acid solution:

The dip method is used when parts are of a size or configuration that can be submerged in a tank. A 3-5 per cent, by volume, water solution of nitric acid is used as the etching solution.

The swab method is used for very large parts, or when examination is to be done on a small area. The swab method employs a similar concentration of nitric acid, but in methyl or ethyl alcohol solution.

Other solutions used in both methods are:

1. Hydrochloric acid, 5-10 per cent by volume.

2. Ammonium or sodium hydroxide, 4-8 per cent by weight.

Alkaline cleaning and rinse tanks can be made from mild steel, while etching and acid tanks should be of stainless steel or non-reactive plastic construction.

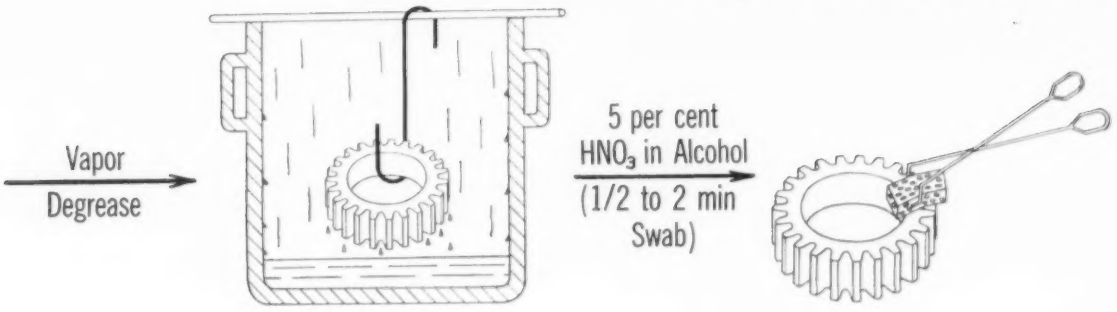
The steps in the dip method are depicted graphically in Fig. 1. Immersion times in the nitric etch vary between parts because of size, composition, and surface condition. Once an immersion time is established for a particular part it can usually be repeated for all similar parts.

Immersion time in hydrochloric acid is varied to produce the proper color contrast.

Fig. 2 depicts the steps in the swab method. Swabbing durations for any specific part should be ascertained on a trial and error basis to obtain proper color contrast for detecting metallurgic defects.

Continued on next page

Fig 2: NITAL ETCH



nital etch

continued

Inspection

Frequency of inspection is a function of part complexity and quality desired. Aviation gears, and most other precision parts are usually checked 100 per cent; (i. e.) each part is examined by nital etch. Magnetic particle inspection and X-ray inspection often supplement the nital etch.

The most important phase of the nital etch inspection is the interpretation of the color changes. There are three major conditions which can be detected by eye:

1. Surfaces in which no overheating has occurred appear light grey to light brown. (Martensite appears light or mouse grey.)

2. Surfaces which have been overheated enough to cause abnormal tempering appear dark grey to black. The darker the color the greater the tempering.

CHART 1

GRINDING DATA

Type of Grinding	Material (50 to 63 Rc)	Wheel	Peripheral Speed ft/min.	Coolant
Form (gears)	AISI 9310, 4340, 8620	A-60-OBY A-80-OBY	4000 to 4500	Socony Vacuum B-2 Standard Oil ES-8
Generate (gears) (worms)	AISI 9310, 8620, 4340	32A-60-J5VBE 32A-80-J12VBEP A120 K7VBE	4000 to 5000	Socony Vacuum B-2 Standard Oil ES-8
Spiral Bevel (gears)	AISI 9310, 8620, 4620	DA80H7V20 A-60-OBY A-80-I8BL	4000 to 4200	Tidewater Afton #2, #8 or Supercool

3. Extremely overheated areas will be rehardened and generally appear as white or grey spots surrounded by large dark grey to black areas. This is indicative of undesirable residual stress and complete local rehardening.

Areas of Importance

It is necessary to know the functionally important areas on most parts. Some areas can stand little defects, while other areas must be perfect.

Figure 3 shows the areas of varying importance for gear inspection. These areas are listed from most to least importance below:

- Active profile
- Blend or fillet
- Bottom or root
- Outside diameter or tip
- Gear ends (when not locating surfaces for thrust).

Burns on the non-drive side are generally not as critical as burns on the profile of the drive side.

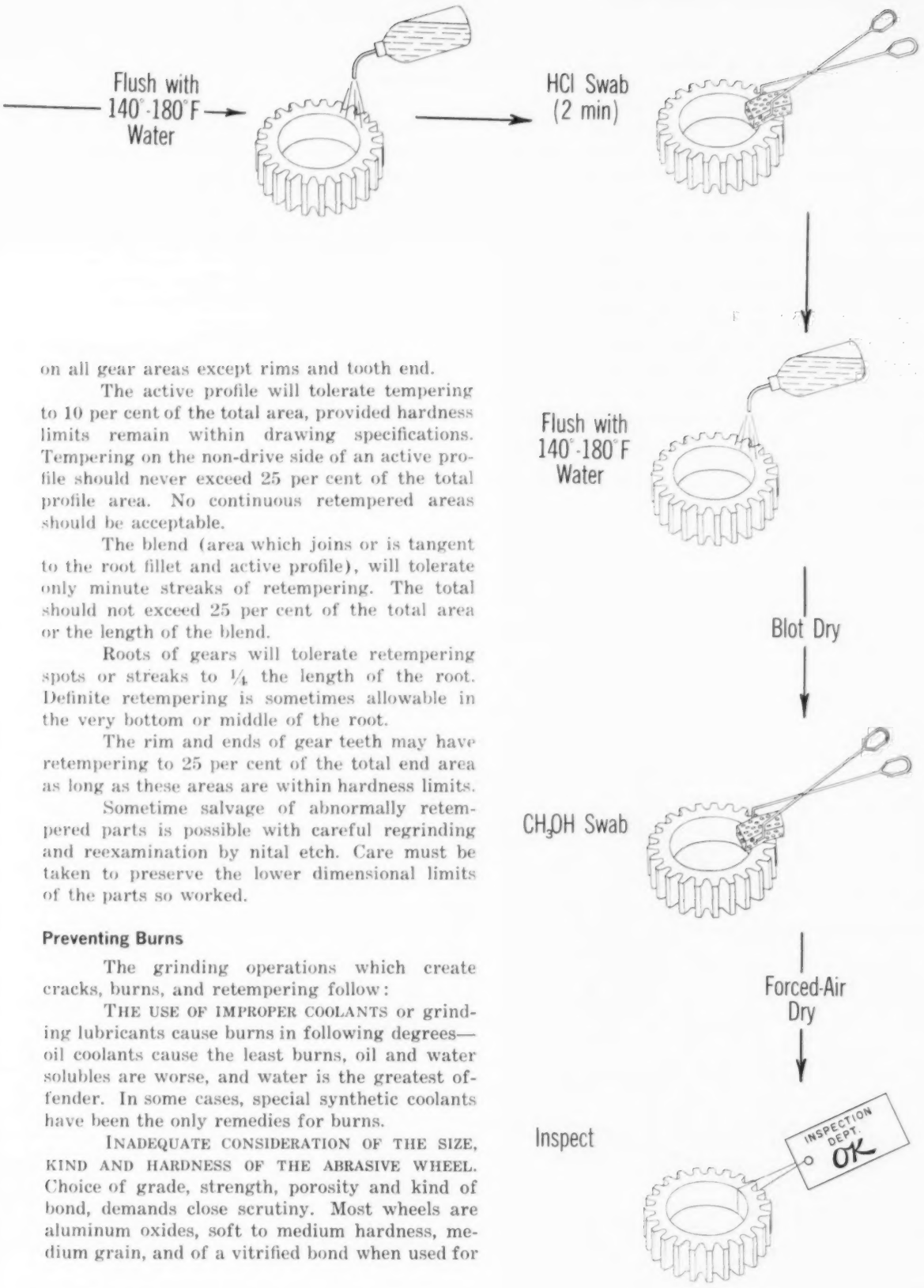
After location of doubtful areas by nital inspection a hardness check should be made. The exact degree of tempering may be measured with the Rockwell superficial hardness tester, using the 15 N scale, or a Vickers Tester with a 30 kg. load. Tempering is acceptable when the hardness check shows the reduction from tempered to untempered area is not more than two points on the Rockwell C scale, and the hardness of the part conforms to the tolerances stated on the drawing or part specification.

Standards

The final decision to accept or reject a part will naturally vary between the type of part and the manufacturing agency. Some good general standards which apply to aircraft gears are:

Rehardening should be cause of rejection

SWAB METHOD



on all gear areas except rims and tooth end.

The active profile will tolerate tempering to 10 per cent of the total area, provided hardness limits remain within drawing specifications. Tempering on the non-drive side of an active profile should never exceed 25 per cent of the total profile area. No continuous retempered areas should be acceptable.

The blend (area which joins or is tangent to the root fillet and active profile), will tolerate only minute streaks of retempering. The total should not exceed 25 per cent of the total area or the length of the blend.

Roots of gears will tolerate retempering spots or streaks to ¼ the length of the root. Definite retempering is sometimes allowable in the very bottom or middle of the root.

The rim and ends of gear teeth may have retempering to 25 per cent of the total end area as long as these areas are within hardness limits.

Sometime salvage of abnormally retempered parts is possible with careful regrinding and reexamination by nital etch. Care must be taken to preserve the lower dimensional limits of the parts so worked.

Preventing Burns

The grinding operations which create cracks, burns, and retempering follow:

THE USE OF IMPROPER COOLANTS or grinding lubricants cause burns in following degrees—oil coolants cause the least burns, oil and water solubles are worse, and water is the greatest offender. In some cases, special synthetic coolants have been the only remedies for burns.

INADEQUATE CONSIDERATION OF THE SIZE, KIND AND HARDNESS OF THE ABRASIVE WHEEL. Choice of grade, strength, porosity and kind of bond, demands close scrutiny. Most wheels are aluminum oxides, soft to medium hardness, medium grain, and of a vitrified bond when used for

gear and tool room grinding of carburized and through hardened steels.

HIGH PERIPHERAL WHEEL SPEEDS cause burning, so speed must be regulated to job. A common cure is lower relative speeds; they give best grinding results. The rate at which stock is removed is a direct cause of the heat generated. Too great a removal of stock per pass causes burns, so the obvious remedy is a shallow feed. A good starting point for rate of removal is 0.001 to 0.002 in. downfeed. Form grinding removes more stock in a pass and unnecessarily appears as a greater offender. This is due to the increased area of contact and greater volume removed in form grinding especially when the fillets are ground. A smaller downfeed will reduce the volume of metal removed to normal limits and eliminate burns.

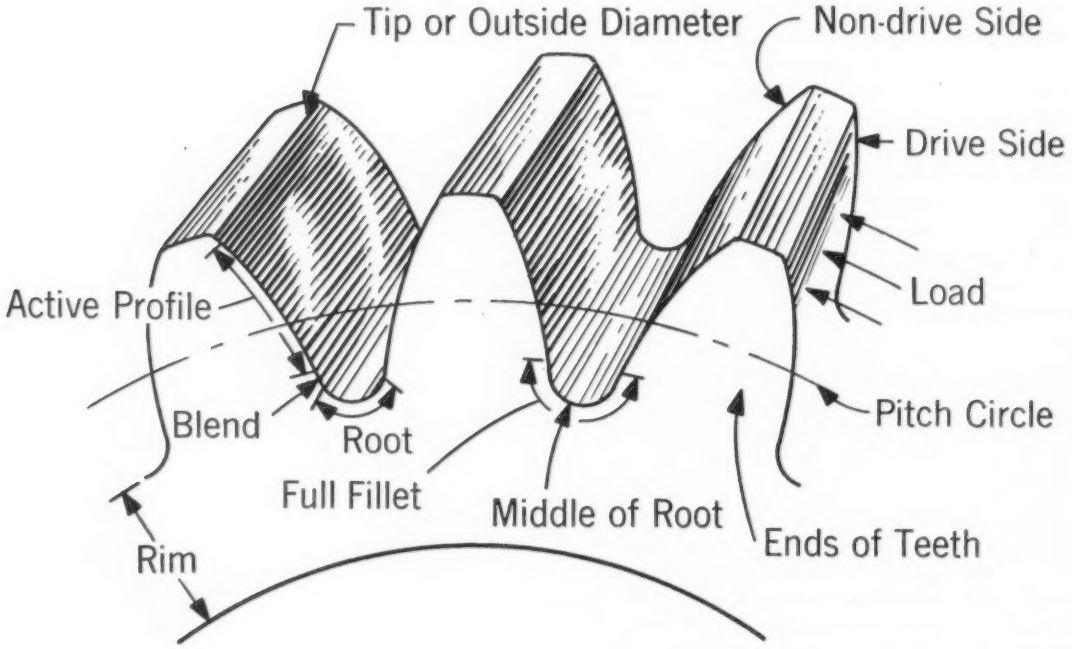
IMPROPER DRESSING OF A WHEEL by poor grade or worn diamonds gives a ragged edge and increases heat generation. New and proper diamonds give a sharp grinding wheel. If the wheel is glazed 0.101 to 0.030 in. stock must be removed from the sides, while a properly conditioned wheel will need only 0.003 in. stock removal during a dressing.

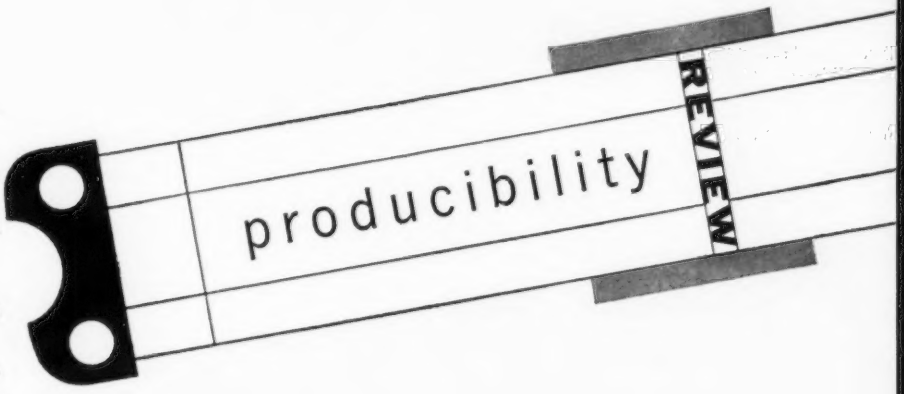
Residual Stresses

Sometimes after a part is ground and passes the nital etch test, it is stored; 24 to 48 hr later, minute hair line cracks appear on the surface. This is the relieving of internal stresses and residual stresses in the part. Closer and minute investigation of the heat treatment cycle is warranted. One of the most common cures for these conditions is to stress relieve the part at 350°F. for one hr after rough grinding. Sometimes a stress relief and freezing cycle is used to stress relieve radical cases.

When major doubt over interpretation of results exists, the competent quality control or engineering personnel must be consulted to determine the final acceptance and rejection of the part.

The proper application of the data presented here will result in reduced costs and scrappage, higher quality, and more satisfactory parts.





DESIGN

The Missile's Metallurgical Miseries.

Prod. Eng., (November 25, 1957), 2 pp.

Brief description of materiel limitations in missile design.

Lubricating with Air—Research Focuses on Gas Bearings.

NICHOLAS CHIRONIS. *Prod. Eng.*, (November 25, 1957), 8 pp.

Possibilities and limitations of hydrodynamic gas bearings as applied to current design.

Rotodyne Report.

Flight, (December 20, 1957), 8 pp.

Background history of development, design features, and performance characteristics are presented.

An Undercarriage in Ultra-High Tensile Steel (Part 1).

G. F. W. MCCAFFRAY. *Ind. Aero.*, (November 1957), 5 pp.

A detailed account of materials methods and design problems encountered in the development of a landing gear utilizing 260,000 to 280,000-psi steel.

MATERIALS

Tube in Strip; New Material for Heat-Transfer Application.

Acft. Prod., (November 1957), 1 p.

Short presentation of typical sections and stock dimensions, as presently available.

Look What's Happening to Honey Combs.

Steel, (October 14, 1957), 4 pp.

A progress report.

Paper, Plastics and Weight-Saving.

Aero., (November 1, 1957), 4 pp.

George May, inventor of Dufalite honeycomb weight-saving construction, reviews his experiences over a period of progressive practical development work.

Condensed Review of Some Recently Developed Materials.

Arranged alphabetically by Trade Names. *Mach.*, (October 1957), 16 pp.

Comprehensive tabulation of material, trade name, properties, applications, and manufacturers' addresses.

"Tube-in-Strip" Heat-Transfer Material.

Eng., (November 1, 1957), 1 p.

Suitable for both air-frame and skin purposes in aircraft construction, may be considered in dealing with heat barrier problems.

Development of Metal-Bonding Adhesive with Improved Heat Resistance.

WADC Technical Report 56-650, PB 121856. Distributed by Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

Improved heat-resisting phenol-epoxy tape for aluminum sandwich bonding.

PRODUCTION

Vacuum Metallurgy.

R. C. BERTOSSA. *Mech. Eng.*, (November 1957), 3 pp.

Brazing combined with vacuum techniques, produces new structural materials for corrosive-chemical containers and for high-temperature flight.

Baby Extruder Makes Precision Shapes.

Amer. Mach., (October 7, 1957), 2 pp.

Small angles and other shapes

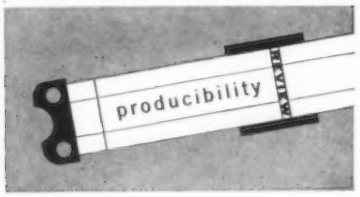
REVIEWED IN THIS ISSUE

Periodicals and Papers

Acft. Prod. Aircraft Production (British)
Aero The Aeroplane (British)
Amer. Mach. American Machinist
Eng. Aeronautical Engineering (British)
Flight Flight
Ind. Aero Industrial Aeronautics (Canadian)
Mach. Machinery
Mech. Eng. Mechanical Engineering Review
Prod. Eng. Product Engineering
Steel Steel Penton Publishing Co.
Tool Engr. The Tool Engineer

Books Received

Profitable Small Plant Management • Chilton
Once Round the Sun • Macmillan •
Aircraft Production Methods • Chilton •
Aircraft Mechanic's Pocket Manual • Pitman
Aircraft Hydraulics • Macmillan •



in high-temperature alloys extruded to close tolerances.

Machining High-Temperature Alloys.

A. B. ALBRECHT. *Mach.*, (October 1957), 5 pp.

Tabulated data of machinability ratings, speeds and feeds, tool grades and geometry, and horsepower requirements.

Ultrasonic Machining Gains.

Steel, (October 14, 1957), 1 p.

Brief descriptions of some applications.

Spin-Forging: A New Machine for the Heavy-Duty Forming of Stainless Steel.

Acft. Prod., (October 1957), 1 p.

Specialized machine operation and capacity.

Printed Circuits for Guided Missiles.

E. D. HELLER. *Amer. Mach.*, (November 4, 1957), 3 pp.

Assembled on semi-automatic lines at Convair's Pomona (Calif.) Missile Division. Change-over from hand wiring to printed circuits in the Navy's latest guided missile—the "Terrier."

Vapour Blasting of Tools; Results of Treating Tungsten-Carbide Tips Before Use and After Grinding.

Acft. Prod., (November 1957), 2 pp.

An effective method for crack-detection, to prevent failure during operation.

Shot Peening Improves Jet Blades.

Tool Engr., (November 1957), 1 p.

Conveyorized operation at Ex-Cell-O Corp.

Skin Milling at 100 Inches per Minute.

HAROLD YOUNG. *Mach.*, (September 1957), 2 pp.

Skin milling of integrally stiffened skins and completely machined structural members.

Machining Honeycomb; Adaptations of Standard Machine-Tools.

K. TEALE. *Acft. Prod.*, (October 1957), 2 pp.

BOOKS RECEIVED

Profitable Small Plant Management.

M. H. GOTTERET. Chilton, 1954. 318 pp. $5.50.

A practical book on management principles which concisely states the basic precepts of scientific management as practiced in well-managed plants. Table of contents include: The small plant in our economy, A management program for small business, Organization, Plant layout, Methods Improvement, Production standards, Wage incentives, Production control, Material control, Manpower management, Job evaluation, Merit rating, and Cost control.

Once Round the Sun.

R. FRASER. Macmillan, 1957. 160 pp. $3.95.

The exciting story of man's attempts to learn the secrets of his physical environment. Dr. Fraser tells why an eighteen-month period was set aside for the International Geophysical Year and what we hope to learn through the coordinated efforts of scientists from 64 countries of the world. Answers are given to questions about sunspots, cosmic rays, "night-glow," and other phenomena. It is also explained how the increased knowledge to be gained about upper and lower atmosphere will be useful to mankind.

Aircraft Production Methods.

G. B. ASHMEAD. Chilton, 1956. 293 pp. $7.50.

The reader of this book is taken through the various departments of aircraft plants to follow and have explained to him the progressive stages of manufacture. The book begins with the master plaster pattern which is a full size model of airplane parts, and takes the reader into the foundry where the forming dies are made. He follows the dies until they meet the blanks that have been cut to suit the various forming machines. He watches the operation of the drop hammer, the stretch press, the brake, etc. The book also covers heat treatment, surface treatment and final assembly methods.

Aircraft Mechanic's Pocket Manual (Fifth Edition).

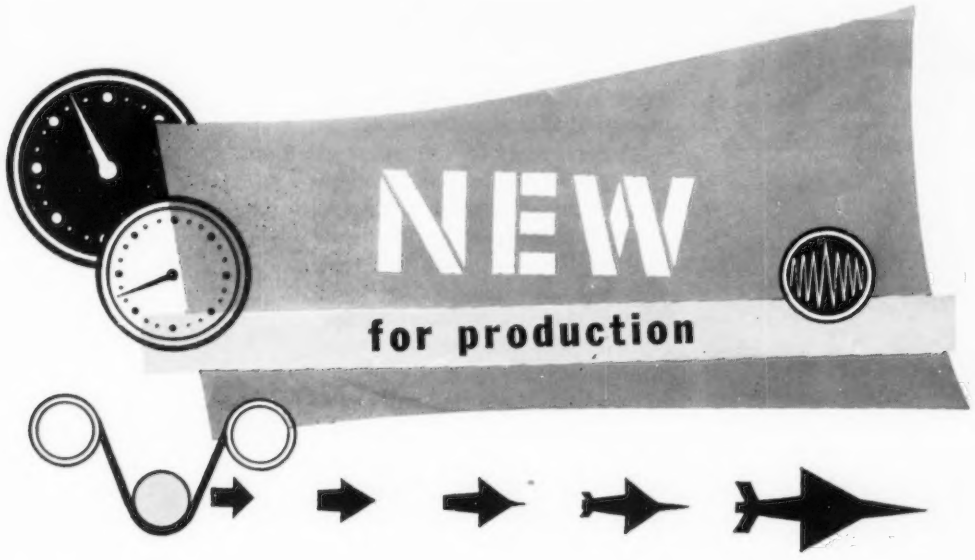
J. A. ASHKOUTI. Pitman, 1957.

Revised to reflect the Aluminum designation changes effective October 1, 1954, this booklet has been used for quick reference by aircraft mechanics and draftsmen. Included are sections on aircraft identification standards, layout methods, shop arithmetic, flat pattern layout, materials of construction, finishes, AN standards, threads, and drilling and reaming.

Aircraft Hydraulics (2 Vols.).

H. G. CONWAY. Macmillan, 1957, 344 pp. $16.

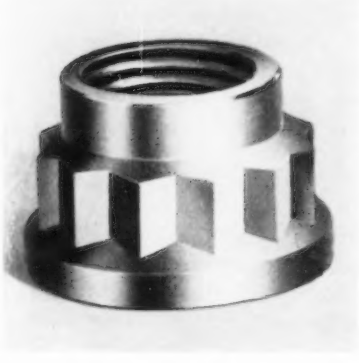
These amply illustrated books are aimed to fill the gap and to cover the broad principles of hydraulics as applied to this field, and to give advice on the design and use of components. Volume 1 is concerned with general problems of hydraulic systems and embraces hydraulic theory, circuits, system installation and testing. Volume 2 discusses component design.



12-POINT LOCKNUT IS LIGHTER THAN STANDARD

A lightweight, high-strength 12-point external wrenching locknut for critical airframe fastening applications is designated Flexloc 42 FLW. It is said to be as much as 25 per cent lighter than, though just as strong as, the standard 12-point aircraft nuts.

One-piece, all-metal locknuts are rated at 180,000 lbs/sq



in. minimum tensile strength. They come in diameter sizes from ¼ through ½ in.

Made of alloy steel, the nuts come either plain or cadmium-plated, with molydisulfide. They are rated for temperatures up to 550°F.

A departure from the standard Flexloc design is the solid locking collar which is squeezed inward in three places to provide vibration-proof locking action once a bolt is threaded into the nut.

Standard Pressed Steel Co.

Circle 243 on postcard for more data

HEAVY-DUTY POWER PACK OPERATES DRIVING TOOL

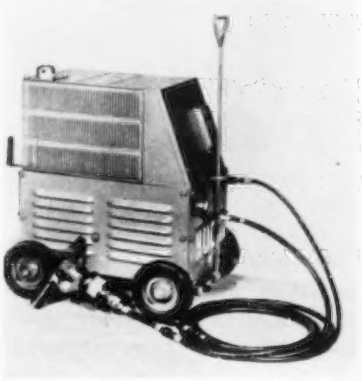
A new heavy-duty hydraulic power pack is designed to operate the Model 146 hydraulic driving tool.

Designated Model 805, the unit is a portable electro-hydraulic generator. Operating at 3000 psi oil pressure, the new power pack is capable of driving the tool at approximately 84 cycs/min. Ruggedly built, it is capable of reliable performance under the most adverse operating conditions.

Drive motor is rated 2 hp at 1800 rpm. It operates on 220/440 v, 3 phase, 60-cyc current. The hydraulic pump has a rated delivery of 3 gpm at 1800 rpm operation.

The combination oil cooler and reservoir assembly have a total oil capacity of 6 qt. This arrangement results in unusual cooling efficiency. Operating temperature is held to a maximum of 12°F above ambient.

A 10-micron replaceable cartridge type filter is provided. A pressure relief valve in the system protects against surges or malfunctions that might sub-



ject components to pressures in excess of 3000 psi. Chassis wheels are 8-in. diam with ball bearings and rubber treads. The unit is furnished with 12 ft of ¼ in. pressure-and-return hose.

Huck Mfg., Co.

Circle 244 on postcard for more data

SOLENOID VALVE FEATURES UNIQUE PLUNGER SEAL

The SV-4900 series multi-purpose solenoid valves are completely dependable for millions of cycles with full operation in any position. These 2-way (normally closed) valves

feature a unique plunger seal design with a soft rubber seal which assures bubble-tight sealing.

They offer stainless steel internal construction and brass body, easy to disassemble and clean, smaller and lighter. Di-

mensions are 2.35 in. high by 1.50 in. wide. They are available with 7 64 orifice rating 130 psi max and 5 32 rated 60 psi max.

These valves are designed for general usage with water, air, steam, inert gases, petroleum and vegetable oils, gasoline, kerosene, and many other semi-corrosive media.

Valcor Engineering Corp.

Circle 245 on postcard for more data

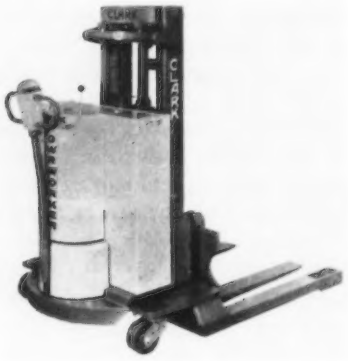
BATTERY-POWERED LIFT TRUCK CALLED: STRADDLE STACKER

Two models of a straddle-type stacker have been added to the Powrworker line of battery-powered hand trucks.

The machine is named the Straddle Stacker. Model 20 STF has 2000 lb capacity; Model 40 STF, 4000 lb. Depending on which of seven sizes of uprights are specified, the unit can lift and tier palletized goods to heights from 94 to 130 in.

A feature of the Straddle Stacker is its articulated drive unit. Mounted on a roller assembly, the drive unit will traverse up and down as much as three inches to compensate for uneven floor conditions. This eliminates the possibility of the drive wheel losing traction when one of the stabilizing casters passes over a high spot.

Forward and reverse direction is controlled by a butterfly switch in the control head on the steering handle. Electric switches make it impossible to direct both forward and reverse current to the drive motor at the same time. The steering handle turns 90 deg in each direction. Brakes are automatically applied when the steering handle is in either vertical or horizontal position, and the handle returns to vertical position



when released by the operator. When the brake is applied the power circuit is broken automatically.

The machine will travel 2.8 mph empty and 2 mph loaded. Without battery, Model 20 STF weighs 2770 lb and Model 40 STF weighs 3190 lb. Fork lengths available are 30, 36, 42, and 48 inches.

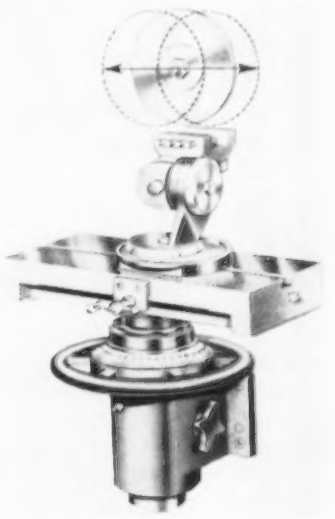
Clark Equipment Co.

Circle 246 on postcard for more data

RECIPROCATING TOOL GRINDER

Off-hand tool grinder models of the double-end reciprocating type, are Style 142 for conventional grinding with vitrified or diamond wheels, and Style 264 equipped with metal-bonded diamond wheels for electrolytic grinding.

Designed to perform two jobs in one, conventional grinding at one end and chip-breaker



grinding at the other, the new grinder styles feature: Adjustable, power-controlled reciprocation of the grinding wheels (the operator only need hold the tool at the pre-set angle). A vertically adjusted table, mounted beneath the reciprocating chip-breaker wheel, accommodates an adjustable tool block fixture which holds the tool in place while grinding the desired angle on the chip-breaker groove.

Other features of the new grinder include variable stroke of 0 to 1½ in.; variable reciprocation of 0 to 220 strokes min; and an in-built, motorized precision grinding spindle, saddle-mounted to reciprocate along hardened and ground bars.

Ex-Cell-O Corporation

Circle 248 on postcard for more data

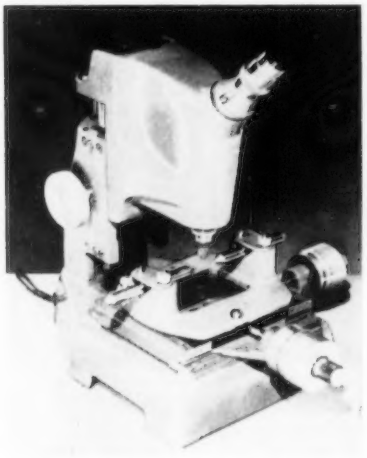
Continued on next page

PRECISE MEASURING SPEEDED BY TOOLMAKERS' MICROSCOPE

Inspection and measurement of drills, taps, jigs, templates, broaches, milling cutters, reamers, and small work parts can now be made with new ease and simplicity.

A combination of optical and mechanical precision, so necessary for consistent accuracy, is embodied in this precision instrument weighing only 23 lb. Its rugged construction assures years of efficient, trouble-free service.

The total range of magnification with interchangeable eyepiece and objective lenses is 27X to 360X. Standard lenses supplied give a magnification of 35X. The eyepiece of the micro-



scope is conveniently angled for comfortable use over extended periods. A knurled ring on the eyepiece permits sharp focusing on the cross lines. A simple screw adjustment aligns these cross lines to a position exactly parallel with stage movement.

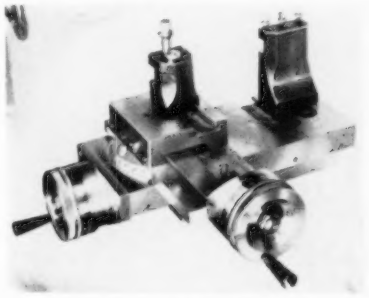
The availability of optional accessories extends the scope of application of this versatile measuring tool. An interchangeable protractor eyepiece permits accurate measurement of angles not possible with the standard eyepiece. A center support easily attached to the cross slide stage, allows the measurement of cylindrical objects. For more efficient use in production work, special eyepiece scales can be made to customer specifications, tailored exactly to fit specific applications.

The DoAll Co.

Circle 250 on postcard for more data

'NO INTERFERENCE' CLAIMED FOR SWIVEL SLIDE

One of the advantages of the Super Slide Rest is the



swivel slide, which is graduated in degrees, may be swung and used for turning operations on the lathe without interference between handles or slides.

It combines the tried and proven features of a conventional slide rest with a new center-driven tool post slide and a new open-side tool post.

This slide rest has the following dimensions and features: Top slide travel is 4½ in. Tool bit size ⅜ x ⅜ in. Hardened and ground screws of ½ in. diam are supported on ball bearings for effortless accuracy.

The rear tool station and tool post are provided as standard equipment. This rear station makes turning and cutting-off, or any other two operations, possible without disturbing the tools.

The Wade Tool Co.

Circle 256 on postcard for more data

WELD ANALYZER RECORDS AS LOW AS 10 MICRO-INCHES

A mobile weld analyzer recorder has been developed which simultaneously depicts

and records current and force applied to electrodes.

Built to withstand rough treatment, the sensitive instrument will reliably record strains as low as 10 microinches inch and currents as low as 1 milliampere. The unit is compact. Weighing 100 pounds and standing 31 in. high, it contains a direct-writing two-channel recorder.

Rubber-tired, non-static, and self-locking casters are employed which permit the unit to be quickly wheeled between welding locations. Record charts are page numbered and are accordion folded to permit easy access for referral, and to eliminate time consuming paper rewinding. Long, pull-out power cord rewinds automatically.

Edin Co.

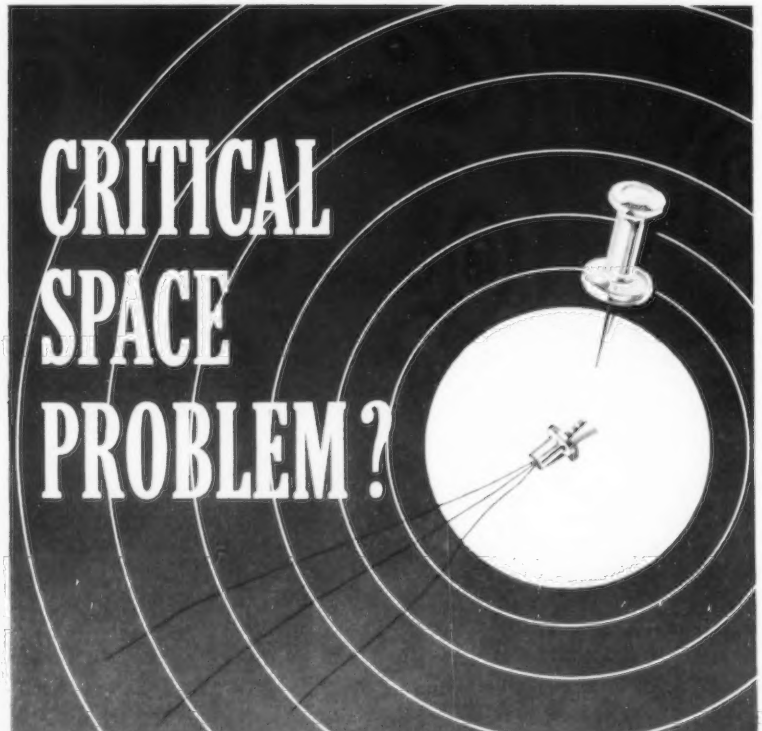
Circle 253 on postcard for more data

SOLUTIONS FOR SIMULTANEOUS PLATING OF TIN AND LEAD

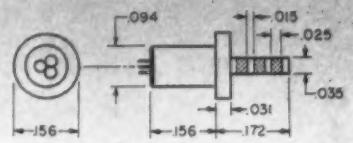
New plating solutions allow tin and lead to be plated singly, or in combination, in any proportion of value to the user. High-lead-content alloy (93 per cent) are suitable for bearing

Continued on next page

CRITICAL SPACE PROBLEM?



Solve It With The Smallest Diameter Slip Ring Ever Made...



Whether your problem is outer or inner space, exclusive, patented*, Electro Tec miniature slip rings give you the assurance of ultra-precision and absolute tolerance in the smallest diameter slip ring available.

Electro Tec Miniatures are produced by a special manufacturing technique that results in accuracy unattainable in so-called "conventional" fabricating or molding methods.

What's more, they give you higher mechanical strength with an absolute minimum of torque friction — *at lower cost!*

There is an Electro Tec engineer near you. He will be glad to visit you and help on your design problems. *Pat. No. 2,696,570

Write for fully illustrated literature.

ELECTRO TEC CORP. *Products of Precision Craftsmanship*

P. O. Box 37C, SOUTH HACKENSACK, N. J.

Continued from page 63

applications; 60-40 tin-lead alloys are ideal for components requiring subsequent soldering. These and any intermediate percentages for special purposes are readily achieved merely by mixing the solution in proper volumetric proportions.

The process makes it possible to plate partial areas without excessive masking or stopping-off. The equipment is mobile, and often work can be handled in place, without dismantling, and subsequent reassembly.

Almost any metal from bismuth to zinc may be deposited, without plating tanks; only a change of plating stylus and electrolyte is necessary. There are now more than 200 different types of application for this equipment.

Dalic Metachemical Ltd.

Circle 247 on postcard for more data

PORTABLE PNEUMATIC SAW HAS ONLY TWO MOVING PARTS

A portable pneumatic power saw and file has been developed which contains only two moving parts for quickly and

easily doing key-hole, deadend, and scroll cutting of plastic material.

The manufacturer tested the power saw on hard thermo plastics as well as on rigid Vinylite, cellulose acetate, polystyrene, fiber-glass reinforced plastics, and Plexiglas. Results were satisfactory.

Air-Speed Tool Co.

Circle 254 on postcard for more data

for full facts on

new materials and components
new production equipment
advertiser's products and services
copies of technical literature

To keep well informed on new products and production equipment, use AIRCRAFT and MISSILES MANUFACTURING'S free reader inquiry service. The new materials, components, technical literature, and production equipment advertised and described editorially in this issue are numbered consecutively and keyed to the post cards below. When information is wanted, circle the corresponding key number on the post card. Extra cards are included for your associates with whom you share your copies of AIRCRAFT and MISSILES MANUFACTURING.

USE FREE READER SERVICE CARDS

Mail this card today for details on products advertised and described in this issue.

Circle item number. Fill in name, title, company, address. Mail it in.

FIRST CLASS
Permit No. 36
New York, N. Y.

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

POSTAGE WILL BE PAID BY

Aircraft and Missiles Manufacturing
P. O. Box 74,
Village Station,
Readers Service Dept. New York 14, N. Y.

Postcard valid 8 weeks only. After that use own letterhead fully describing item wanted. **FEB. 1958**

Please send further information on items circled below.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260
261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300

YOUR NAME ..... TITLE .....
COMPANY .....
PLANT ADDRESS .....
CITY ..... ZONE ..... STATE .....

advertisers in this issue

In order to obtain further details on items advertised or described in this issue, circle the key number (s) on the postpaid card and mail it.

93
Apex Machine & Tool Co.
Universal joints

84
Behlman Engineering Co.
AC power source

88
Electro Tec Corp.
Miniature slip rings

91
Hunter Mfg. Co.
Space heaters

87
Invo Spline, Inc.
Master spur gears

83
King Fifth Wheel Co.
Formed and welded rings

85
Sciaky Bros., Inc.
Counter-control welders

90
Sealol Corp.
Gas and fluid seals

82
Sharon Steel Corp.
Steel fasteners

92
Slip Ring Co. of America
Slip ring assemblies

89
Stackpole Carbon Co.
Custom engineered contacts

86
Titan Tool Co.
Stud drivers and pullers

MATERIALS & COMPONENTS

Alphabetical List of Products

193 **Camera, aerial**
Fairchild Corp.

197 **Capacitor, tantalum**
Kennemetal Inc.

189 **Chromallizing process**
Chromalloy Corp.

186 **Compound, silicone rubber**
Union Carbide Corp.

183 **Cooling unit**
The Garrett Corp.

196 **Films, adhesive**
Minnesota Mining & Mfg. Co.

209 **Heat exchanger**
AiResearch

206 **Jack, nylon-tip**
Whitso, Inc.

195 **Nylon plate**
Polymeric Corp.

202 **Pump, hydraulic**
Vickers Inc.

198 **Pump, titanium shaft**
Mallory-Sharon Metals Corp.

201 **Thermometers, resistance, platinum**
Trans-Sonics, Inc.

200 **Transceiver, VHF**
Topp Manufacturing Co.

207 **Turbonator**
General Electric Co.

204 **Tubing, Heat-resistant**
Continental Diamond Fibre

181 **Valves, metering**
A. V. Stone & Co., Inc.

Alphabetical List of Companies

209 **AiResearch**
Heat exchanger

189 **Chromalloy Corp.**
Chromallizing process

204 **Continental Diamond Fibre**
Tubing, heat-resistant

193 **Fairchild Corp.**
Camera, aerial

183 **The Garrett Corp.**
Cooling unit

207 **General Electric Co.**
Turbonator

197 **Kennemetal Inc.**
Capacitor, tantalum

198 **Mallory-Sharon Metals Corp.**
Pump, titanium shaft

196 **Minnesota Mining & Mfg. Co.**
Films, adhesive, supported

195 **Polymeric Corp.**
Nylon plate

Postcard valid 8 weeks only. After that use own letterhead fully describing item wanted. **FEB. 1958**

Please send further information on items circled below.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260
261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300

YOUR NAME ..... TITLE .....

COMPANY .....

PLANT ADDRESS .....

CITY ..... ZONE ..... STATE .....

FIRST CLASS
Permit No. 36
New York, N. Y.

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

POSTAGE WILL BE PAID BY

Aircraft and Missiles Manufacturing
P. O. Box 74,
Village Station,
Readers Service Dept. **New York 14, N. Y.**

WORTH ASKING FOR

295 **Knobs, hard, aluminum**

order your new subscription now!

181 **A. V. Stone & Co., Inc.**
Valves, metering

200 **Topp Manufacturing Co.**
Transceiver, VHF

201 **Trans-Sonics, Inc.**
Thermometers, resistance, platinum

186 **Union Carbide Corp.**
Compound, silicone rubber

202 **Vickers Inc.**
Pump, hydraulic

206 **Whitso, Inc.**
Jack, nylon-tip

NEW FOR PRODUCTION

Alphabetical List of Products

253 **Analyzer, weldment, mobile**
Edin Co.

244 **Generator, electro-hydraulic, portable**
Huck Mfg. Co.

248 **Grinder, tool reciprocating**
Ex-Cell-O Corp.

246 **Lift-truck, battery powered**
Clark Equipment Co.

245 **Locknut, 12-point**
Standard Pressed Steel Co.

250 **Microscope, toolmakers**
The DoAll Co.

254 **Saw, pneumatic, portable**
Air-Speed Tool Co.

256 **Slide rest, swivel**
The Wade Tool Co.

247 **Solutions, plating**
Dalic Metachemical Ltd.

245 **Valve, 2-way, plunger-seal**
Valcor Engineering Corp.

Alphabetical List of Companies

254 **Air-Speed Tool Co.**
Saw, pneumatic, portable

246 **Clark Equipment Co.**
Lift-truck, battery-powered

247 **Dalic Metachemical Ltd.**
Solutions, plating

250 **The DoAll Co.**
Microscope, toolmakers

253 **Edin Co.**
Analyzer, weldment, mobile

248 **Ex-Cell-O Corp.**
Grinder, tool, reciprocating

244 **Huck Mfg. Co.**
Generator, electro-hydraulic portable

243 **Standard Pressed Steel Co.**
Locknut, 12-point

245 **Valcor Engineering Corp.**
Valve, 2-way, plunger-seal

256 **The Wade Tool Co.**
Slide rest, swivel

FEB. 1958

new Subscription Order

Please enter a new complimentary subscription to AIRCRAFT and MISSILES MANUFACTURING.

Name: ..... Title .....

Company: .....

Plant ☐ Home ☐ (Check one) Address: .....

City: ..... Zone ..... State .....

Specific Products Manufactured .....

FEB. 1958

new Subscription Order

Please enter a new complimentary subscription to AIRCRAFT and MISSILES MANUFACTURING.

Name: ..... Title .....

Company: .....

Plant ☐ Home ☐ (Check one) Address: .....

City: ..... Zone ..... State .....

Specific Products Manufactured .....

Postcard valid 8 weeks only. After that use own letterhead fully describing item wanted. FEB. 1958

Please send further information on items circled below. LI

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260
261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300

YOUR NAME ..... TITLE .....

COMPANY .....

PLANT ADDRESS .....

CITY ..... ZONE ..... STATE .....

WORTH ASKING FOR

Alphabetical List of Items

293 **Actuators, modular**
Airborne Accessories Corp.

280 **Casting, stainless**
Copper Alloy Corp.

281 **Data sheet, wire, precision**
Chicago Telephone Supply Corp.

290 **Dehydrator, gas**
Selas Corp. of America

285 **Eqpt., metalworking, precision**
Winslow Manufacturing Co.

289 **Fans, Axial-flow**
Borg-Warner Corp.

295 **Knobs, hand, aluminum**
Northwestern Tool and Engineering Co.

284 **Lubrication systems, air-borne**
The Texas Co.

283 **Metal, zirconium, zircaloy**
Metals and Controls Corp.

287 **Mouldings, rubber**
E. F. Houghton & Co.

292 **Silicone rubber, fabric and sheets**
The Connecticut Hard Rubber Co.

291 **Surface plate, flatness check**
Engis Equipment Co.

279 **Table, physical properties**
Norton Co.

278 **Tester, tension and compression**
Allegany Instrument Co., Inc.

294 **Timers, precision-interval**
The A. W. Haydon Co.

271 **Thermometer, straight-form**
W. C. Dillon & Co.

286 **Voltmeter**
North Atlantic Industries, Inc.

FIRST CLASS
PERMIT No. 18

Philadelphia 39, Pa.

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

—POSTAGE WILL BE PAID BY—

Aircraft and Missiles Manufacturing

CHESTNUT & 56TH STS.

PHILADELPHIA 39, PA.

FIRST CLASS
PERMIT No. 18

Philadelphia 39, Pa.

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

—POSTAGE WILL BE PAID BY—

Aircraft and Missiles Manufacturing

CHESTNUT & 56TH STS.

PHILADELPHIA 39, PA.

FIRST CLASS
Permit No. 36

New York, N. Y.

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

POSTAGE WILL BE PAID BY

Aircraft and Missiles Manufacturing
P. O. Box 74,
Village Station,
New York 14, N. Y.

Readers Service Dept.

Alphabetical List of Companies

293 **Airborne Accessories Corp.**
Actuators, modular

278 **Allegany Instrument Co., Inc.**
Tester, tension and compression

289 **Borg-Warner Corp.**
Fans, axial-flow

281 **Chicago Telephone Supply Corp.**
Data sheet, wire, precision

280 **Copper Alloy Corp.**
Casting, stainless

292 **The Connecticut Hard Rubber Co.**
Silicone rubber, fabric and sheets

271 **W. C. Dillon & Co.**
Thermometer, straight-form

291 **Engis Equipment Co.**
Surface plate, flatness check

294 **The A. W. Haydon Co.**
Timer, precision-interval

287 **E. F. Houghton & Co.**
Mouldings, rubber

283 **Metals and Controls Corp.**
Metal, zirconium, zircaloy

295 **Northwestern Tool and Engineering Co.**
Knobs, hand, aluminum

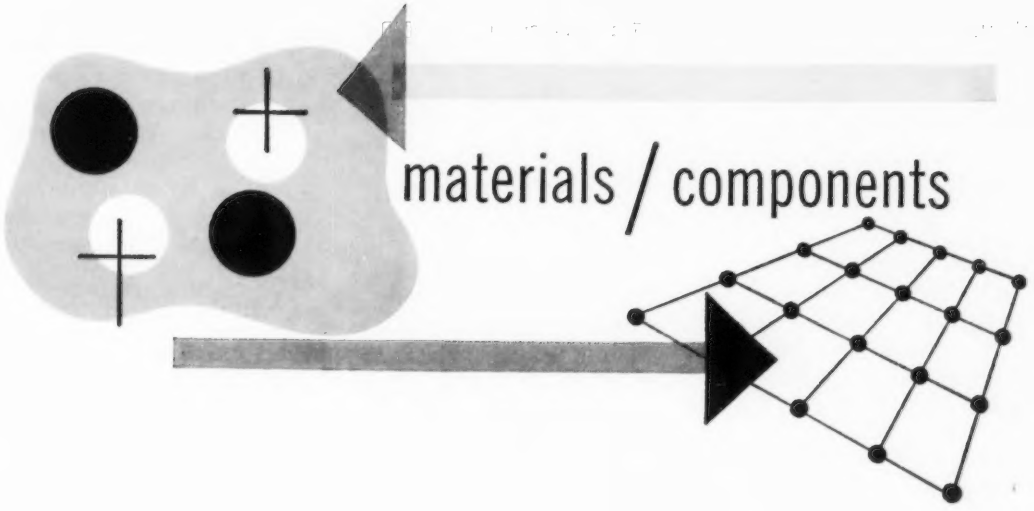
279 **Norton Co.**
Table, physical properties

286 **North Atlantic Industries, Inc.**
Voltmeter

290 **Selas Corp. of America**
Dehydrator, gas

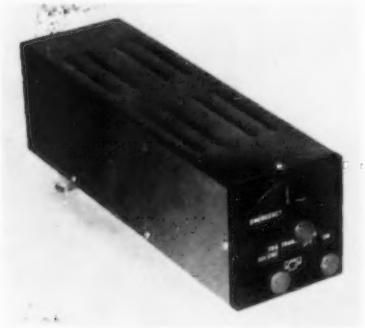
284 **The Texas Co.**
Lubrication systems, air-borne

285 **Winslow Manufacturing Co.**
Eqpt., metalworking, precision



Standby VHF Radio Weighs Only 5 lb.

VHF-transceiver for use as a standby communication unit is crystal-controlled and



covers any two-megacycle band from 118 to 132 mc. The entire unit fits a standard three and one-quarter inch panel opening and extends behind the instrument panel. Complete with its own built-in power supply, the transceiver operates from either 14 or 28-v sources. The weight is less than five lb.

Topp Manufacturing Co.

Circle 200 on postcard for more data

Platinum Thermometers Cemented to Any Surface

Platinum resistance thermometers can be installed on any surface, flat or curved, metallic or non-metallic, for accurate temperature measurement. The protective cover of the resistive element is cemented or welded directly to the thermal surface and forms an isothermal system which gives a true skin temperature reading.

Trans-Sonics, Inc.

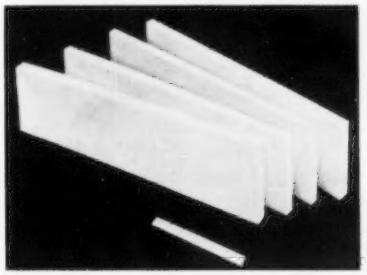
Circle 201 on postcard for more data

Sizes of Nylon Plate Upped to 1.5 in. Thick

Polypenco nylon plate is now available in thicknesses up to 1.5 in.

The new sizes are available in nylon 101 and Nylatron "GS" (molybdenum disulphide filled) formulations. The standard width is 10 in. and lengths range to 4 ft.

Nylon plate provides a combination of high wear re-



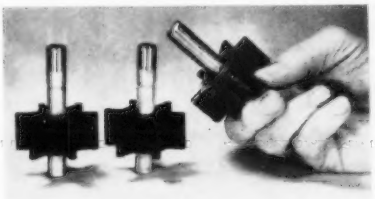
sistance and resilience, low surface friction, non-scratching or galling characteristics and sound deadening properties.

Polymeric Corp.

Circle 195 on postcard for more data

Titanium Pump Shaft Has High Corrosion Resistance

Titanium shaft which withstood two months of pumping highly corrosive ferric chloride, with no signs of damage is



held alongside two other shafts. The other shafts show effects of corrosion after less than one hour of service. Severe corrosion caused leakage and failure of the pump. The titanium pump shaft was made from commercially pure titanium.

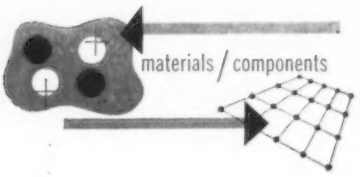
Mallory-Sharon Metals Corp.

Circle 198 on postcard for more data

Compact Cooling Unit Made For Electronic 'Black Boxes'

A compact, lightweight package for keeping electronic "hotboxes" at a cool working temperature has been made available by a West Coast manufacturer.

The unit offers precision temperature control for electronic equipment operating in sealed pressurized compart-



ments. It is composed of an efficient circulating fan, joined with a heat exchanger, which features high heat transferring capacity per exchanger volume. These factors result in units of relatively small size and weight.

The fan circulates air through the heat exchanger, where it is cooled and then forced over the electronic components within hermetically sealed compartments. Liquid or ram air may be used in the heat exchanger as cooling agent, traveling crosswise to the circulated air.

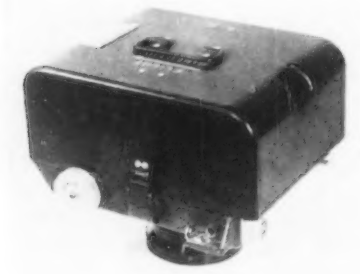
AiResearch Mfg. Div.

Circle 209 on postcard for more data

Aerial Camera Developed For Pilotless Aircraft

Designated the KA-28, a 17-lb camera, loaded with film for 4½ x 4½ in. negatives and equipped with controls for Image Motion Compensation (IMC), may be installed in either a manned aircraft or a pilotless drone, for low level reconnaissance.

A single, 28-volt DC battery system operates both the flash cartridge ejector and the camera system. Fourteen flash cartridges, mounted seven on each side of the fuselage, are ejected alternately by electrical ignition of the primers by a stepping switch. The stepping switch is actuated by the film transport mechanism to insure perfect coordination between the position and speed of the film and the flash peak.



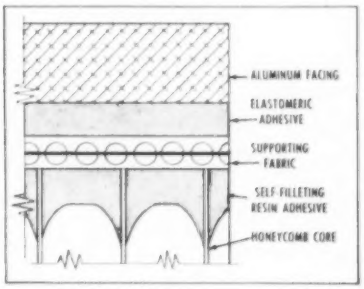
Fairchild Corp.

Circle 193 on postcard for more data

Supported Adhesive Films Improve Sandwich Bonds

Two heat curing, supported, elastomeric film adhesives that provide high peel and beam shear strengths for sandwich panel construction, have been added to the Scotch-Weld line.

Designated AF-200 and AF-201, the two consist of a high strength elastomeric adhesive film on one surface and a self-filleting adhesive film on the other surface. The elastomeric adhesive bonds to the facing and the self-filleting adhesive bonds



to the core of the honeycomb sandwich panel.

Composite adhesive film AF-200 yields beam shear, flexure strengths of 1580, 1530, and 1385 psi at temperatures of —67°, 80°, 180°F respectively. Aluminum honeycomb panels bonded with AF-200 adhesive have peel strengths of 18, 24 and 21 in. lb/in. at temperatures of —67°, 80°, 180°F respectively.

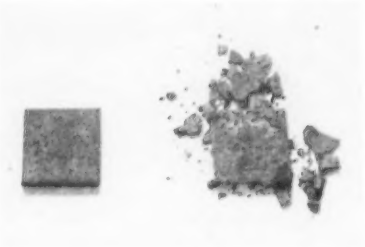
Sandwich assemblies are bonded in a heated press at a temperature of 350°F for 50 minutes under a pressure of 25 psi.

Minnesota Mining & Mfg. Co.

Circle 196 on postcard for more data

Better Engine Performance By Metallurgical Process

The Chromallizing process, which creates an integral alloy surface rich in chromium, has been adapted to use on the nickel or cobalt alloys used in internal combustion engines and gas turbines. The process is not applicable to conventional steels and works only on high nickel



and high cobalt alloys. Type 310 stainless, Inconel X, N-155 gas turbine alloy can be treated.

Only minor dimensional changes occur and resultant surfaces withstand prolonged exposure to gases at 1800° to 2000°F, in the presence of lead bromide, lead sulfide and sulfur dioxide.

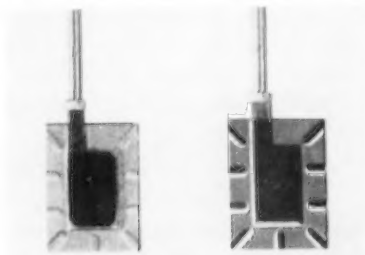
Photo shows treated panel (left) and untreated panel (right) after 22 hr exposure to high temperature corrosive atmosphere.

Chromalloy Corp.

Circle 189 on postcard for more data

Integral Cooling Unit Made for Electronic Gear

A cooling unit has been developed that is packaged as



an integral part of the airborne electronic equipment which it cools.

The unit is mounted on a lightweight, but structurally

sound, 20 x 24 in. honeycomb base designed as part of the container.

Two fans and a heat exchanger complete the cooling unit.

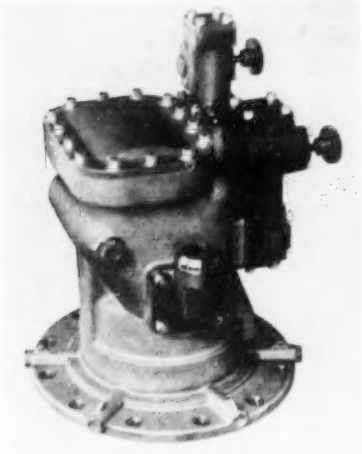
One fan circulates nontoxic sulfur hexafluoride (SF_6) through the heat exchanger and over the electronic equipment. The other fan simultaneously draws cooling ambient air through the heat exchanger crosswise to the flow direction of the gas.

The Garrett Corp.

Circle 183 on postcard for more data

Hydraulic Pump Delivers 5000 psi for Launchings

Operating pressure to 5000 psi is provided by this new Vickers pump. It was designed for test stand use and other applications where 3000 psi is



normally required with a call for reserve power. It has passed WADC 1000-hour endurance test operating at 5000 psi for over 100 hours.

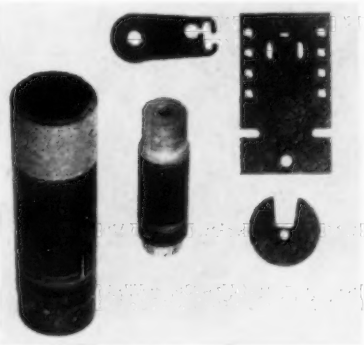
A high pressure, long life version of a standard model; fluid delivery is from 0 to 38.2 gpm, pressures from 0 to 5000 psi. Handwheels provide ready manual adjustment of maximum pump delivery (yoke angle) and maximum load pressure.

Vickers Inc.

Circle 202 on postcard for more data

Standard Tooling Works Phenolic Laminates

Heat resistant "Dilecto" phenolic laminates and "Celoron" molded tubing both with heat-resistant felted-asbestos base are suited for missile and aircraft applications, since they



retain high mechanical strength after very short exposure to operating temperatures as high as 3500°F.

Illustration shows laminates cold punched by standard punching methods and castings threaded and counterbored with conventional machines.

Continental Diamond Fibre

Circle 204 on postcard for more data

Turbonator Revealed As Lightweight Power Package

A new constant-frequency power package described as the lightest available to the aircraft industry and called a turbonator weighs 96 lb, consists of a 24,000 rpm axial turbine on a common shaft with a high-speed alternator, and produces 40 kva at 400 cps.

Features of the turbonator include an air bearing in place of conventional oil or grease bearings and a self-cooling capacity which eliminates special cooling requirements at high ambients.

Either ram or compressor bleed air can be used as the driving medium, up to Mach 3.5.

General Electric Co.

Circle 207 on postcard for more data

Tantalum Stock Available In Capacitor Grade Purity

Capacitor grade tantalum metal is the latest product development of Kennametal Inc.

Bars, sheets, foil, wire and granules made from tantalum of 99.9 per cent purity will soon be available in production volume.

High purity tantalum is being utilized in the manufacture of capacitors used in aircraft, missile, radar, fire control, and navigational equipment.

Kennametal Inc.

Circle 197 on postcard for more data

Jack Inserts Quickly and Locks Self in Place

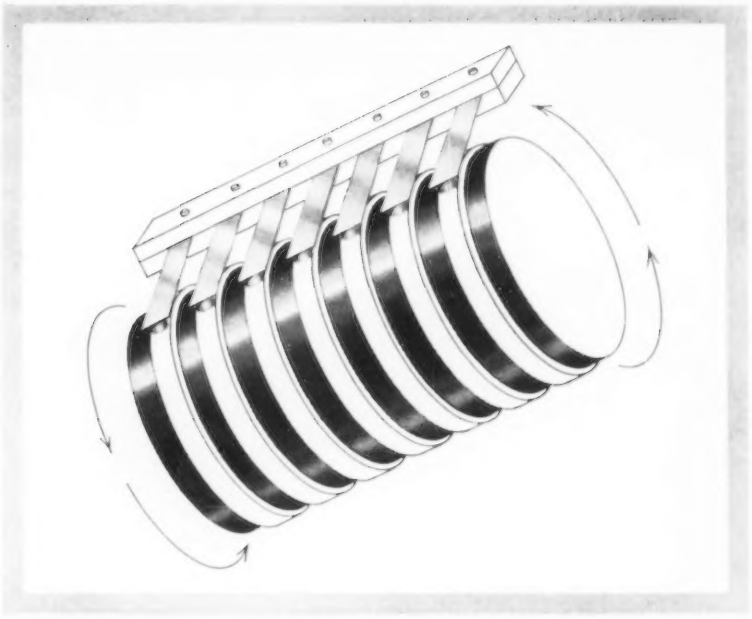
Fast installation and "vibration-proof" service are featured in a new molded nylon tip jack. The one-piece jack requires no threads, nuts, or lock washers. When the fluted nylon body is pushed through a ¼-in. cabinet or chassis hole by drill press, arbor press or other me-

chanical means, the flutes compress, then expand to provide holding action that requires approximately 50 lbs pull to release.

High contact pressure and low electrical resistance are provided by a heat-treated, silver-plated beryllium copper contact. The terminal lug is hot solder dipped for easy solder connection. The component accommodates a standard 0.081 in. diameter tip plug and is rated at 10,000 volts D. C.

Whitso, Inc.

Circle 206 on postcard for more data



Minimizing SLIP-RING CONTACT R-F Noise Levels

Wherever contacts slide or operate against rotating surfaces, there is a good chance that specially developed Stackpole silver-graphite grades will assure good performance with a marked reduction in r-f interference levels.

They have, for instance, been used with outstanding success on applications ranging from radar antenna operating units to calculating machines; from aircraft prop-pitch rotators and de-icers to midget motors; for temperature measurements and on rotating equipment, and in many other uses.

They have assured more stable contact resistance and increased contact life. Equally important, Stackpole's unique high-temperature process for brazing these little contacts to their support arms has greatly simplified assembly operations. Overall costs have been reduced accordingly. Shielding and filters have proved unnecessary in many cases.

The usual method is to operate a silver-graphite contact against a coin-silver slip ring. In some cases, silver-graphite or copper-graphite operating against copper give satisfactory results. It all depends on the application—and that's where Stackpole's years of specialized experience in custom engineering contact material combinations from metal powders pays worth while dividends to contact users.

Details of your slip-ring contact (or brush) application will bring prompt recommendation based on a careful study of the equipment requirements and operating conditions.

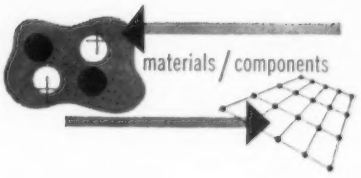
STACKPOLE CARBON COMPANY, *St. Marys, Pa.*

STACKPOLE

CUSTOM ENGINEERED

CONTACTS

Hundreds of grades in SILVER-GRAPHITE • SILVER-LEAD OXIDE • SILVER-NICKEL SILVER-MOLYBDENUM • SILVER-TUNGSTEN • COPPER-GRAPHITE • GOLD-GRAPHITE • SILVER-COPPER-GRAPHITE • SILVER-IRON OXIDE . . . and other special combinations mixed to exacting specifications and processed from powders.



Two-Way Restrictor Valve Made of Stainless Steel

Two-way restrictor valves, for precise metering of gas or liquid flow are available in stainless steel alloy.

Metering action is controlled by a precision sharp-edged orifice, with uniform flows in both directions.

The all stainless steel construction eliminates storage life problems of most non-metallic seals. The valves use metal-to-metal seals. The valve orifice is protected by filters of stainless steel mesh (Rigimesh).

A. V. Stone & Co., Inc.

Circle 181 on postcard for more data

Silicone Rubber Compound Exceeds AMS-3301B Spec

K-1044R, a commercially available silicone rubber compound, passes AMS-3301B specification, eliminates the stepwise post cure of thick sections and makes possible low compression set without the use of toxic additives. K-1044R provides high tear, high elongation, high tensile strength, high ASTM No. 1 oil resistance, low moisture absorption, and good dielectric properties.

Union Carbide Corp.

Circle 186 on postcard for more data

Zirconium and Zircaloy

New technical data Bulletin IND-16 gives the manufacturer's range of specifications on strip and foil in Zirconium and Zircaloy as a single metal or clad with invar or stainless steel. The bulletin notes the quality control methods, as well as the testing and production facilities available.

Metals & Control Corp.

Circle 283 on postcard for more data

Lubrication Systems

Central Air-Borne Lubrication Systems is the name of recently published booklet evaluating some modern methods of lubricant application for industrial use.

The Texas Co.

Circle 284 on postcard for more data

Precision Metalworking

Jet turbine bucket production and inspection equipment is described in new pamphlets also covering other specialized types of precision devices.

Winslow Manufacturing Co.

Circle 285 on postcard for more data

Voltmeter

A self-contained, multifunctional, phase-angle voltmeter that performs many laboratory, production, and field tests is described in detail in new Series 200 Bulletin. The instrument is currently in use in the aircraft and missile field. Operating principles, range, accuracy, and other features are included.

North Atlantic Industries, Inc.

Circle 286 on postcard for more data

Rubber Mouldings

A complete program for the supply of specialized moulded rubber parts is described in a new four-page folder. Services are highlighted for the design, production, and storage of rubber, and rubber-to-metal mouldings.

E. F. Houghton & Co.

Circle 287 on postcard for more data

Compressed Air Dryers

New 12-page bulletin describes new models of heatless, self-activating, zero-dewpoint dryers designed to prevent moisture fouling of instruments, controls, testers, circuits, chemicals, etc. Capacities available are 1 to 5400 scfm, and 100 to 3000 psi.

Van Products Co.

Circle 288 on postcard for more data

Axial Flow Fans

New four-page Bulletin No. 5703 describes axial flow fans for air supply and exhaust applications requiring intermittent or continuous duty at ratings from 16 to 5000 cfm, and higher, over a wide pressure range. Included is a detailed enumeration of aircraft, electronic, commercial, and marine applications providing actual and potential design ideas.

Borg-Warner Corp.

Circle 289 on postcard for more data

Gas Dehydrators

Bulletin SC-1013 depicts dehydrators, designed specifically for continuous moisture removal from gases such as Carbon Dioxide, Carbon Monoxide, Hydrocarbons, Nitrogen, Oxygen, Natural Gas, Hydrogen, Inert Gases, Propane, Butane, etc. Inlet pressures may range to 150 psig for standard design, and to over 3500 for special applications. Outlet dewpoint may be maintained as low as −100°F.

Selas Corp. of America

Circle 290 on postcard for more data

Physical Properties Tables

"Norton Electrochemicals . . . Gifts of the Firebird" is the title of a new 16-page booklet describing the physical properties of 23 products of the high temperature, electric furnace.

Technical data is conveniently prepared in tables for ready reference. The description of each of the materials includes present and possible future uses, availability of sizes and quantities, and physical characteristics.

Among the materials described are silicon carbide, zir-

worth asking for:

technical literature listed here is available without charge from the various manufacturers

(Continued from page 73)

conium oxide, zirconium carbide, calcium zirconate, boron carbide, boron nitride, boron, other borides, carbides and nitrides, and fused oxides.

Norton Co.

Circle 279 on postcard for more data

Thermometers

Straight form thermometers are described by new illustrated literature. Developed for use on top of tanks and boilers or in other installations where it would be impractical to utilize the standard angle form unit, these instruments are featured in ten popular or special ranges. They are available calibrated in Fahrenheit or Centigrade, in stem lengths from 2½ to 72 in., and 3 or 5 in. diam dials.

W. C. Dillon & Co.

Circle 271 on postcard for more data

Stainless Casting

The way in which three new foundry methods are combined to produce a complex stainless steel casting is the subject of a 4-page reprint.

The casting in question, the main body of a fuel ignitor valve for a jet engine, is made of a high heat resistant tool steel and must be defect-free. Shell core, hot sleeve, and CO_2 sand hardening; the three methods employed to solve the production problems, are described and illustrated.

Copper Alloy Corp.

Circle 280 on postcard for more data

Tension and Compression Tester

New engineering bulletins No. 625-1 introduces the model 625A, High Rate Tester which provides a completely calibrated stress-strain record of the deformation of a specimen at rates as high as 6000 in. per min. Operating principle, specifications, and other test equipment are also included.

Allegany Instrument Co., Inc.

Circle 278 on postcard for more data

Precision Wire Data Sheet

Data Sheet 170 illustrates and gives full technical details on the new CTS line of smaller space factor, more stable bobbinless precision wire fixed resistors with the unique "floating" element. Eleven standard rectangular types and four standard tubular types are illustrated with their wattages, dimensions, resistances, and performance characteristics given.

Chicago Telephone Supply Corp.

Circle 281 on postcard for more data

Surface Plate Check

New booklet introduces an improved method of measuring flatness of surface plates, machine beds, ways, and other surfaces. The method is based upon the use of the Microptic Testgraph, on which readings of the Microptic Auto-Collimator are expressed in "topographic" curves.

Engis Equipment Co.

Circle 291 on postcard for more data

Silicone Rubber

The properties of 50, 60, and 70 durometer silicone rubber sheets and fabric reinforced silicone rubber sheets for —85° F to 500°F applications are detailed in a new two-page data pamphlet. These products meet AMS 3302, 3304, and 3320 specifications.

The Connecticut Hard Rubber Co.

Circle 292 on postcard for more data

Safety Shoes

Complete details on 72 different safety shoe styles for men and women are given in new 16 page catalog. Also included is a buying guide on how to select the best shoe and construction for different industrial conditions and hazards.

Lehigh Safety Shoe Co.

Circle 277 on postcard for more data

Modular Actuators

A line of 64 standard, interchangeable actuator components which can be assembled into hundreds of combinations is described in new four-page catalog 57A. These actuators are grouped in three broad operating capacity classifications, or modules: L12, to 350 lb; L16, to 2500 lb; and L20, to 3500 lb. Included are various engineering data.

Airborne Accessories Corp.

Circle 293 on postcard for more data

Timing Devices

Bulletin RC-3000 describes a new series of precision interval timers. These are hermetically sealed units, available with either chronometrically governed D.C. motors or synchronous A.C. motors. The unit is designed for panel mounting through a 6⅜ x 3⅜ in. flange, and is provided with an adjusting knob to allow rapid and accurate setting of calibrated dials. Outlines with mounting dimensions are also included.

The A. W. Haydon Co.

Circle 294 on postcard for more data

Hard Knobs

A flyer sheet depicts new, aluminum hand knobs for tooling or other purposes. Star and hexagon-type knobs are featured; a full-scale tracing template is also included to facilitate drafting.

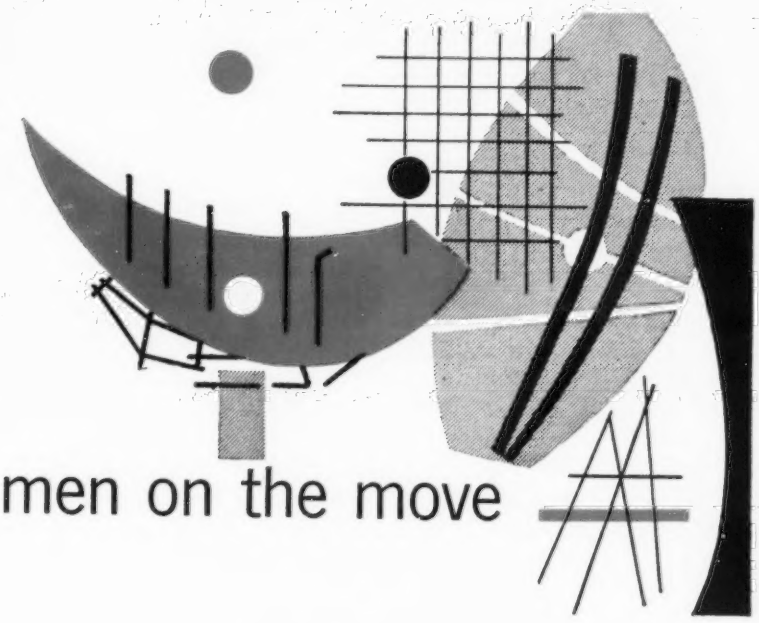
Northwestern Tool and Engineering Co.

Circle 295 on postcard for more data

ROBERT W. JORGENSEN
Richardson

ALFRED C. EKBERG
Pratt & Whitney

JOHN W. ROWAN
Vickers



men on the move

ROBERT W. JORGENSEN, vice president and director of plastic sales for The Richardson Co., Melrose Park, Ill., has been elected chairman of the laminated products section of the National Electrical Manufacturers Association.

In addition to NEMA, Jorgensen is a member of the Society of the Plastics Industry. His other memberships include the American Marketing Assn., American Management Asso., Cornell Society of Engineers, and the Executives Club of Chicago.

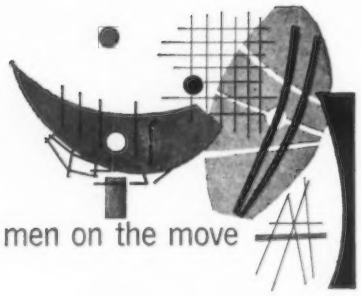
ALFRED C. EKBERG has been named district manager at the Detroit office of Pratt & Whitney Co. He succeeds Samuel J. Matchett who is retiring from the company after 34 years service.

Mr. Ekberg, a graduate of Worcester Polytechnic Institute, joined the company as a special apprentice in 1936. He entered the sales department of the company's machinery division after completion of his apprentice training in 1939. From 1946 until the present he served the company as a sales engineer attached to its Cincinnati branch office. His most recent assignment has been in the Indianapolis area.

JOHN W. ROWAN has been appointed service manager, Detroit Aero Hydraulics service section, Vickers, Inc. Mr. Rowan will be responsible for product improvement, field service, unit repair, and overhaul activities for the area east of the Rocky Mountains.

Most recently chief of the Piston Unit development group of the Aero Hydraulics Div., Mr. Rowan has been with the company since 1949 and has contributed to the development of their high output hydraulic pumps and motors, alternator drives, and hydraulic winch systems for aircraft. He graduated in mechanical engineering from Lawrence Institute of Technology, and has had 15 years' experience in aircraft hydraulics.

Continued on next page



RICHARD A. MAHER has been appointed vice president of engineering for Hoffman Laboratories, Inc.

Maher was previously chief engineer at Hoffman Laboratories, the military research, development, and production subsidiary of Hoffman Electronics Corp.

Prior to joining Hoffman in February of this year, Maher was manager of engineering for the Government and Industrial Div. of the Philco Corp., Philadelphia. Before that he was Director of the Research and Development Dept. for Radio and Television at the Crosley Div., Avco Manufacturing Corp., Cincinnati.

DEWEY H. NELSON has been promoted to Assistant Manager of the Becco Chemical Div., Food Machinery and Chemical Corp., Buffalo, N. Y. Mr. Nelson will continue in the capacity of Sales Manager, a position he has held since November 1956.

Mr. Nelson is a graduate of M.I.T., and was a pilot during World War 2. He joined Becco in October 1947, working first in the company's Special Projects department and later in the Research department. In 1951, he was transferred to the Sales department and became Midwest District Manager in Chicago in April 1953. He returned to Becco's Buffalo headquarters in August 1956 as Assistant to the Sales Manager.

CHESTER W. HOLMES has joined United Aircraft Products, Inc., Dayton, Ohio, as assistant to the president, Edward L. Ladd. Holmes will handle special assignments with reference to executive sales.

The appointment was made to meet future requirements for versatility in the realm of customer contact in line with increased activities in the missile and rocket industry. Holmes will supplement the existing force primarily in industrial and commercial fields.

His duties will include market studies and new product investigation.

ROBERT KAHN heads the sub-systems procurement, a new department to concentrate on aircraft subsystems obtained from vendors at the Fort Worth plant of the Convair Div. of General Dynamics Corp.

He was assistant B-36 project engineer in 1948; RB-36 project engineer in 1950; B-58 subsystems project engineer in 1952; and was appointed manager of material in 1955.
He will manage procurement of subsystems which represent nearly fifty per cent of the entire Convair cost of producing B-58 supersonic bombers.

DR. HARVARD L. HULL, vice president of Litton Industries, Inc., Beverly Hills, Calif., has resigned to become president of the Nucledyne Corp., a wholly-owned subsidiary of Cook Electric Co., Chicago.

He assisted in the development of electromagnetic isotope separation of Uranium 235 in the "Manhattan Project," and was responsible for developing hot laboratory equipment, used in most nuclear facilities, while at Argonne National Laboratory.

CHESTER W. HOLMES
United Aircraft Products

ROBERT KAHN
Convair

DR. HARVARD L. HULL
Litton

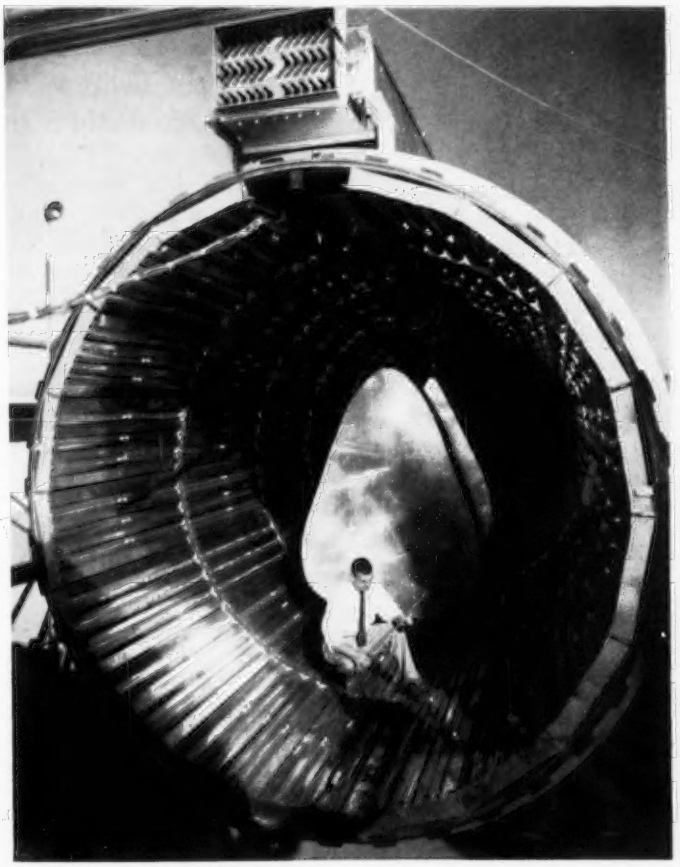
industry notes

Test Chamber Simulates 100,000 Ft and 830°F

Altitudes up to 100,000 ft and aerodynamic heat up to 830 F generated by flight at Mach 3 speeds will be simulated in a new million-dollar electronics cooling test stand just completed for the F-106A Delta Dart at Convair Division of General Dynamics Corporation.

First of its type in the aviation industry, the vacuum test chamber is a steel cylinder 12 ft in diameter and 70 ft long. It will enclose a full-scale fuselage to test how effectively the electronic and air-conditioning components in this advanced all-weather jet interceptor perform under extremes of altitude and temperature.

Heat from two sources affects performance of the electronic guidance and fire control equipment in the F-106A: (1) That generated by the equipment itself; and (2) that which soaks into the electronic systems from air friction on the outside surface of the aircraft. Accordingly, the electronic equipment must be air-conditioned to hold temperatures within limits the electronic components will tolerate and still function properly.



Built of $\frac{3}{8}$-in. steel, the test chamber is divided into two 35-ft sections, one of which is mounted on wheels. This section is rolled back on a track to expose the forward half of the F-106A fuselage and permit adjustment of the electronic systems. The fuselage system itself is mounted on a dolly to permit easy removal or positioning within the test cell.

When the chamber halves are closed, a hydraulic mechanism seals the chamber and engages electrical connections

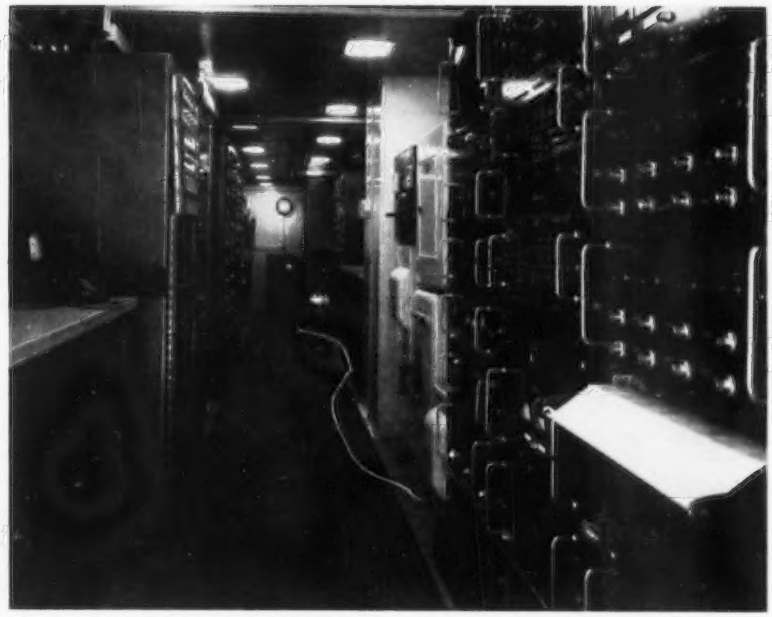
through bus bars mounted at the top of the test stand.

To simulate various altitudes, air is evacuated from the test chamber by two-stage Elliott steam ejectors and semi-barometric condensers. These may be operated simultaneously or singly, depending upon conditions desired in a particular test. Two Keeler boilers of 20,000-lb/hr capacity feed steam to the ejectors. Sea water is pumped from nearby San Diego Bay to condense the steam in the ejectors and thus pump air out of the chamber.

To simulate the aerodynamic heating that occurs on the aircraft's surface at high speeds, the interior walls of the test chamber are lined with reflector panels on which 750 infrared tubular quartz lamps are mounted. Filament temperature of these 2,500-w lamps reaches 4,000°F, the same as that measured in the heart of the afterburner blast of a J-57 turbojet engine.

Surface of the test fuselage is divided into seven heating zones. The temperature of each zone is sensed by a separate thermocouple system. Signals from these areas are transmitted to a Leeds-Northrup Speedomax Controller. This in turn regulates the power output from Westinghouse Ignitron tubes to the individual heat zones.

Evaluation of data gathered from this facility will help design and technical groups at Convair to improve reliability of the F-106A's electronic equipment and to increase the aircraft's capability as a part of the nation's aid defense system.



Slow Vans, Swift Missiles Are Paradoxical Partners

Awkward, slow-moving vans, and sleek, swift ballistics missiles make a strange but necessary pair in the nation's ballistic missile program.

This paradox exists because the vans contain essential checkout equipment for use in insuring missile electronic components are functioning reliably before the missile is launched from field sites.

The 37x9.5 ft vans are outfitted by the Missile and Ordnance supply department of the General Electric company as part of the prime contract in Atlas and Thor nose cone development. They contain beacon equipment, pulse amplitude modulation equipment, pulse width modulation equipment, and a maze of other electronic gear.

Lawmaker Asks Formula For Defense Profits

Rep. William E. Hess (R., Ohio) declared in an article in *Planes*, official Aircraft Industries Association publication, that the next session of Congress must review renegotiation and other legislation "to make certain that any artificial barriers to a sound defense program are eliminated, and that the fullest advantage is obtained from our free enterprise system."

Representative Hess also urged that attention be given to the methods of computing excess profits. "There are several cases," he said, "where the regional office of the Renegotiation Board has determined that the profits of a company are not excessive, and the Board in Washington, working from the same set of facts, determines that profits are excessive by as much as $10,000,000." On the other hand, he pointed out, there are instances where the Renegotiation Board in Washington has reduced the amount of excess profits determined by the regional office.

The Ohio lawmaker said the net result of this "wide disparity of excessive profit determination within the Renegotiation Board" is cause for grave concern "since it places contractors in a corporate limbo of not knowing where they stand."

reinforced plastics

potentials as a material for space flight explored at SPI convention in Chicago

One of the most serious deterrents to our impending conquest of space, the development of materials to cope with nature, was explored at the 13th Conference of the Reinforced Plastics Division of SPI in Chicago, February 4-6.

Papers, representing the experimental findings and speculative thinking of the leading scientists involved in developing reinforced plastics, will examine the potential of this neoteric class of materials in overcoming the extreme requisites for space travel. The Speed-Temperature-Radiation Session, and the Processing Session was devoted to problems in the aircraft and missile industries.

The Major Problems

- HEAT, caused by aerodynamic friction and propellant oxidation.
- EROSION, caused by impact with non-gaseous substances in the air.

Hypersonic flight, introduces the heat problem. For example, at speeds of Mach 13, temperatures of 7200°F are generated. No known solid is stable at this temperature.

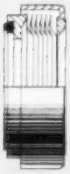
An important consideration in the evaluation of new materials is that environments created or encountered at hypersonic velocities cannot be simulated in the laboratory. The water stabilized arc, which delivers a gas containing a substantial fraction of oxygen at temperatures up to 14,500°F and heating rates of 2000 Btu per sq ft per sec, is a recently developed apparatus which may render a valuable assist in overcoming this problem. The value of this test machine was discussed by the General Electric Company.

Polyester, silicone, and heat resistant phenolic laminates were evaluated at Wright Air Development Center, for resistance to high intensity radiation. Changes in the physical, mechanical, and electrical properties were taken as the criteria of resistance. Laminates of a thickness representative of those used in radome construction were exposed to a uniform radiation from a Mitchell Process Projector carbon arc source operating at 6000°F. Drop in ultimate tensile strength, resistance to charring and blistering, and degradation of electrical properties were discussed by H. S. Schwartz.

Results of a Martin Company study on the combined effects of high temperature and high velocity gas erosion by N. D. Miller and E. L. Strauss. Glass - phenolic, glass - silicone, and asbestos-phenolic laminates retain an appreciable degree of structural integrity after sixty seconds in this environment, despite severe surface charring and erosion.

WADC has also evaluated subsonic and supersonic rain erosion on radomes. The complete test program and its results will be presented by G. P. Peterson. Specimens were tested with and without special erosion resistant coatings on rocket sleds, on ballistic projectiles and on aircraft.

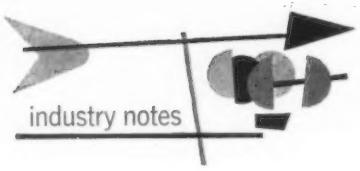
WHICH SEAL WILL SOLVE YOUR PROBLEM?

Seals drawn to same scale.				
Type of Seal	**Standard**	**Modified**	**Bellows**	**Shaft Surface**
Pressure (PSI)	1000	500	250	75
Speed (FPM)	15,000	15,000	15,000	15,000
Temperature (°F)	350° to 450°	−360° to 350°	−360° to 700°	500° to 700°
Uses	Fluids including aviation fuel, synthetic lubricants, etc.	Rocket motors, HNO_3, H_2O_2, NPN, LOX, Ethylene Oxide	Applications calling for all-metal, high temperature sealing	Sealing gaseous mediums in a minimum amount of axial space
Send for	Bull. #7	Specially enginered	Bull. #18	Bull. #19

CAUTION: Maximum conditions indicated for each type do not necessarily imply that all are available in a single seal. Sealol engineers will gladly recommend the seal best suited to the operating conditions of your particular application. Write today . . . no obligation, of course!

SEALOL CORP
423 Post Rd., Providence 5, R. I.

SEALOL



INDUSTRY STATISTICS

Source: Bureau of the Census and Civil Aeronautics Administration.

VALUE OF NET SALES AND BACKLOG OF COMPLETE AIRCRAFT, AIRCRAFT ENGINES, AND PROPELLERS

All data are in Thousands of Dollars

NET SALES

Product and Type of Customer	Nine Months 1957	Nine Months 1956
Complete Aircraft and Parts		
For U. S. Military Customers	$4,041,000	$3,176,000
For Other Customers	913,000	557,000
Total—Aircraft and Parts	$4,954,000	$3,733,000
Aircraft Engines and Parts		
For U. S. Military Customers	$1,524,000	$1,193,000
For Other Customers	291,000	226,000
Total—Engines and Parts	$1,815,000	$1,419,000
Aircraft Propellers and Parts		
For U. S. Military Customers	$ 97,000	$ 68,000
For Other Customers	32,000	24,000
Total—Propellers and Parts	$ 129,000	$ 92,000
Total U. S. Military Customers	$5,662,000	$4,437,000
Total Other Customers	1,236,000	807,000
Other Products and Services	$1,734,000	$1,254,000
Total All Products	$8,632,000	$6,498,000

BACKLOG

Product and Type of Customer	September 30 1957	September 30 1956
Complete Aircraft and Parts		
For U. S. Military Customers	$ 6,534,000	$ 9,454,000
For Other Customers	2,744,000	2,797,000
Total—Aircraft and Parts	$ 9,278,000	$12,251,000
Aircraft Engines and Parts		
For U. S. Military Customers	$ 2,475,000	$ 3,255,000
For Other Customers	642,000	679,000
Total—Engines and Parts	$ 3,117,000	$ 3,934,000
Aircraft Propellers and Parts		
For U. S. Military Customers	$ 152,000	$ 113,000
For Other Customers	37,000	44,000
Total—Propellers and Parts	$ 189,000	$ 157,000
Total U. S. Military Customers	$ 9,161,000	$12,822,000
Total Other Customers	3,423,000	3,520,000
Other Products and Services	$ 1,847,000	$ 2,021,000
Total All Products	$14,431,000	$18,363,000

NUMBER AND VALUE OF CIVIL AIRCRAFT SHIPMENTS

Month	Units 1957	Units 1956	Value in Thousands 1957	Value in Thousands 1956
January	584	537	$ 48,431	$ 22,325
February	523	614	49,278	32,139
March	665	656	46,465	29,562
April	642	692	57,723	30,229
May	662	714	83,965	35,145
June	580	648	69,326	40,270
July	515	507	70,480	32,280
August	509	681	62,825	46,294
September	456	613	54,745	41,137
October	464	508	45,522	50,089
November	511	472	47,130	51,518
December		563		43,168
Total Year		7,205		$454,156
Total 11 Mos.	6,111	6,642	$635,890	$410,988

AIRFRAME WEIGHTS OF CIVIL AIRCRAFT SHIPMENTS

Month	Thousands of lbs. 1957	Thousands of lbs. 1956	Avg. Aircraft 1957	Avg. Aircraft 1956
January	1,574.9	986.2	2,697	1,837
February	1,554.0	1,265.4	2,971	2,061
March	1,615.6	1,200.4	2,429	1,830
April	1,871.6	1,227.1	2,915	1,773
May	2,548.0	1,362.2	3,849	1,908
June	2,104.0	1,460.8	3,628	2,254
July	2,086.0	1,162.3	4,051	2,293
August	1,940.6	1,600.7	3,813	2,351
September	1,631.1	1,389.2	3,577	2,266
October	1,446.3	1,583.6	3,117	3,117
November	1,474.8	1,550.7	2,886	3,285
December		1,413.7		2,511
Total Year		16,202.3		2,249
Total 11 Mos.	19,846.9	14,788.6	3,248	2,227

SHIPMENTS OF PISTON ENGINES FOR CIVILIAN AIRCRAFT

Month	Units 1957	Units 1956	Value 1957	Value 1956
January	920	930	$ 12,445,000	$ 6,800,000
February	902	976	13,596,000	6,923,000
March	1,010	1,065	13,975,000	7,600,000
April	950	949	14,388,000	7,967,000
May	1,020	1,038	15,160,000	9,459,000
June	933	977	15,636,000	8,682,000
July	801	996	12,748,000	8,420,000
August	776	1,037	8,603,000	8,036,000
September	728	793	10,150,000	9,938,000
October	921	902	13,638,000	10,877,000
November	878	911	9,880,000	11,391,000
December		925		12,370,000
Total Year		11,499		$108,263,000
Total 11 Mos.	9,839	10,574	$140,219,000	$ 95,893,000

TOTAL HP. OF AIRCRAFT PISTON ENGINE SHIPMENTS FOR CIVILIAN USE

Month	Total Hp. (in thousands) 1957	Total Hp. (in thousands) 1956	Avg. Hp. per Engine 1957	Avg. Hp. per Engine 1956
January	604.4	383.3	657	412
February	647.0	401.3	717	411
March	679.2	431.7	672	405
April	668.2	431.4	703	455
May	715.8	503.5	702	485
June	730.4	459.4	783	470
July	590.4	444.6	737	446
August	425.6	431.8	548	416
September	482.8	481.0	663	607
October	628.3	536.0	661	594
November	473.0	556.6	539	611
December		595.6		644
Total Year		5,656.2		492
Total 11 Mos.	6,645.1	5,060.6	675	479

Tool Sparking Hazards Studied by Navy

"Non-sparking" hand tools are no more effective than those of steel in preventing accidental ignition of explosive or combustible atmospheres, according to a conclusion of a Navy report just released for industry use through the Office of Technical Services, U. S. Department of Commerce.

The conclusion was reached during a survey of sparking characteristics and safety hazards of metallic materials. It was found that sparks or impacts and subsequent ignitions can result from use of low sparking materials such as copper. It was also shown that metallic sparks can be produced by contact between a non-sparking and a sparking metal.

Another significant result was the observation that non-metallic sparks can be produced by low velocity impact of metal on quartzitic rock. Impact was indicated as a more hazardous source of ignition than friction sparks, particularly in firedamp, or methane-air, encountered in mining operations.

Sparking theory and methods of spark testing are included in PB 131131 *Sparking Characteristics and Safety Hazards of Metallic Materials*, H. Bernstein, U. S. Naval Gun Factory, Apr. 1957.

WS 110A Ordered

A contract for a supersonic intercontinental bomber has been awarded to North American Aviation, Inc.

The bomber previously referred to as the WS 110A will be capable of speeds in excess of 2,000 miles an hour for long distances at ceilings of over 70,000 ft.

The approved project is the result of competitive proposals and an exhaustive research program launched in 1955.

Six Step Space Program of American Rocket Society Submitted to President Eisenhower

The full-scale report submitted by the American Rocket Society (ARS) to President Eisenhower calls for immediate initiation of a long-term national space flight program, to be administered by a new independent government agency with broad powers in this area.

The report, written before Sputnik I was fired, notes that, while the military aspects of space flight have been carefully considered, many important scientific, commercial and politico-military applications of even greater long-range significance have been overlooked. Moreover, no government agency exists with powers broad enough to plan a program of the type required, and existing space flight efforts are being hampered by the lack of such an agency.

As a result, immediate initiation of a national space flight program and establishment of an overall supervisory agency, similar to the Atomic Energy Commission or the National Advisory Committee for Aeronautics, are urged. Major prerequisites to the success of these measures, the report points out, would be adequate financing and the formulation of a clear-cut agency broad enough to include all but the strictly military applications of space flight.

Six Step Program

Toward this end, the report recommends a six-step space flight program which the current state of the art would make possible even without any major technological breakthroughs in the next 20 years. These are:

1. Orbital vehicles with payloads in the order of thousands of pounds within five years.
2. Payloads of 100 to several hundred pounds placed on or about the moon within 5 to 10 years.
3. Payloads of several hundred pounds as far out as the orbits of the nearer planets within 5 to 10 years.
4. Manned orbital vehicles and manned space flight between any two points on the earth's surface within 10 years.
5. Manned flights around the moon in 15 years.
6. Manned two-way moon flights, including landing, within 20 years.

These goals are in accordance with the philosophy of the report which stresses concentration on those phases of space flight which have immediate utility; which can employ the available state of the art to the greatest extent and which can be realized with modest extrapolation of existing techniques; and to initiate on a modest scale the research necessary to develop the specific astronautical technology that will make long-range goals feasible.

More than extrapolation

Space flight, it is pointed out, cannot be regarded simply as an extrapolation of missile technology. Nonetheless, certain of the goals of both missile technology and space flight are similar.

The immediate purposes of this separate space flight program would be, first, to increase

Continued on next page

HUNTER SPACE HEATERS

for mobile and portable military shelters

- designed and produced in accordance with military specifications for space, equipment and personnel heating requirements.
- 5 basic models — each custom-engineered for a wide variety of applications — for ground control and maintenance equipment in missile systems, radar, microwave and radio communication systems, etc.
- BTU/Hour range: from 15,000 to 60,000.
- multi-fuel-burning models; also models which burn any type gasoline.
- all models air-circulating, thermostatically controlled, all designed for cold starts as low as — 65°F.

Other Hunter equipment for military applications: engine heaters; unpowered, instant lighting torches; refrigeration units.

GET THESE BROCHURES TODAY!

for complete specifications and details

MH-162 "Hunter Space and Personnel Heaters"

MH-166 "Hunter Engine Heaters"

MH-167 "Hunter Instant-Lighting Torches"

HUNTER MANUFACTURING CO. 30537 AURORA RD. SOLON, OHIO

Circle 91 on Inquiry Card, page 65

the dividend from current military expenditures by applying them in astronautical projects; second, to apply the best of the present and future states of the art to astronautical ends; third, to improve the state of the art in those areas not covered by existing military requirements; and, fourth, to develop a true astronautical technology, separate and apart from missile technology.

New Agency

The report recommends that, in the absence of an existing agency which has all the necessary capabilities, a new agency, temporarily referred to as the Astronautical Research and Development Agency (ARDA), be established and charged with formulation and execution of this program.

Primary control of ARDA, the report states, should rest in the hands of persons with experience in the development of rocket vehicles, although certain governmental agencies, as well as the scientific community and the general public, would also be represented on the agency.

ARDA would not compete with industry, nor with the Armed Forces. It would basically be a management agency, operating by contract to industry, research organizations, etc.; conducting theoretical studies and operating its own research laboratories when necessary, and evaluating scientific information about space flight; supporting Armed Forces R&D activities not only by making its own information available, but by training personnel, helping in tracking operations, etc.; and serving the various branches of the government in an advisory capacity. It would also represent the US in astronautical projects carried out on an international basis.

Continued on next page

Hydraulics ENGINEER

SERVO COMPONENTS

A medium size company located in California is looking for a Hydraulics Engineer to take charge of their servo components in areas of research, design and development. Should have at least B.S.M.E. degree or equivalent. Must have experience in aircraft and missile hydraulics with emphasis on the design of hydraulic servo components plus knowledge of related manufacturing processes. Experience in the design of electrohydraulic servo valves, desirable. Will consider a senior engineer ready to assume greater responsibility. State in first letter: Age, education, training, positions held and earnings. All replies will be held in strictest confidence.

Reply to Box 5, AIRCRAFT AND MISSILES 5601 Chestnut St., Philadelphia 39, Pa.

finest quality

SLIP RING ASSEMBLIES

made by EVERY known process . . .

UNITIZED ONE-PIECE CONSTRUCTION

100 Ring Missile Guidance Slip Ring Low Torque, Low Noise

Only Slip Ring Co. of America produces precision slip ring assemblies by every known process to meet your particular requirements — Transfer, Injection and Compression Molded, Cast, Fabricated, Vacuum Impregnated, Electro Deposited, Metal Sprayed, Printed Circuit, Mercury Pool. Sizes, .020" to 72" Dia. Circuits, 2 to 200 rings. Finishes, 2 micro inch RMS. Temperature, 650°F continuous. Vibration, 300 G's. Hi pot, up to 15,000 volts. Longer life through wider material selection. Dielectrically superior insulating materials. Minimum noise with precious metals. Engineering consultation available.

SLIP RINGS — BRUSH ASSEMBLIES — COMMUTATORS — SEALED ASSEMBLIES

Write for Literature

SLIP RING CO. OF AMERICA

3612 West Jefferson Blvd. Dept. AM Los Angeles 16, California

Representative sales engineers in major cities throughout the United States and Canada.

Circle 92 on Inquiry Card, page 65

Navy Orders Mach 2 Inertially Guided Regulus

Chance Vought Aircraft, Inc., has received a Navy contract for approximately $26 million for continued evaluation and production of its submarine-launched Regulus II guided missile.

The contract calls for an undisclosed number of both test and tactical versions of the Mach 2 missile, and comes on the heels of contract awards totaling $300,000,000 for Vought's F8U-1, -2, and -3 fighter aircraft. This brings the company's backlog of unfilled orders to approximately $675,000,000.

Fired from submarines and inertially guided, Regulus II will achieve high accuracy through a navigation system which can check its course automatically with existing landmarks close to its target and make last minute corrections.

The missile is powered and guided all the way from launch to target, unlike ballistic missiles which must fall earthward in free flight like an artillery shell.

Man Can Soon Fly Aircraft in Space

"An expenditure of between $200 and $300 million now would enable the U. S. to put a manned aircraft into space in less than three years," the president of the Aircraft Industries Association declared recently. In an article in AIA's official publication, *Planes*, Orval R. Cook indicated the aircraft industry has available today most of the hardware and all of the basic knowledge needed to send a man into space.

He also declared that missiles, especially ballistic types, have captured world attention as no other weapon in the history of man. Largely ig-

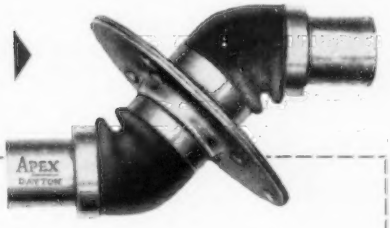
built to meet—and exceed specification requirements

Unique structural design, and sealed, lubricant-retaining covers found only on Apex universal joints make possible universal joint applications never before feasible. Available in a full range of sizes, in heavy-duty (MS-20271) and light-duty (MS-20270) types, all Apex military universal joints meet or exceed all specification requirements.

APEX universal joints for aircraft and ordnance applications

One standard hub, and one drilled and splined hub end are used on this Apex covered universal joint in a wing flap actuating system.

Double universal joint for bulkhead mounting. Both joints and the center bearing are protected and provided with sustained lubrication.



and engineered for special applications

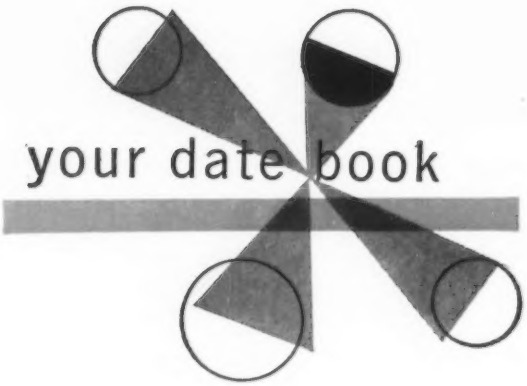
Apex offers a complete engineering service on new or special universal joint applications. For critical systems having little or no initial backlash, or to maintain a lash-free system for extended periods of service, Apex can furnish universal joints with backlash limits ranging below .08°. Zero backlash can be achieved, if desired.

Catalog 28 contains complete information, and includes a very helpful Application Data Sheet. Write, on your company letterhead please, for your copy.

1933 *A Quarter Century of Service to Industry* **1958**

THE
APEX
MACHINE & TOOL CO.
1930 South Patterson Blvd.
DAYTON 2, OHIO

Phantom view of APEX covered universal joint which operates efficiently in wet or dry, corrosive or abrasive atmospheres, and in extremes of temperatures.



what	fourth annual college of engineering open house
who	rutgers university
where	state university campus
when	february 21-22

◆

what	third annual jet age conference
who	air force association
where	washington, d. c.
when	february 26-27, 1958

◆

what	gas turbine power conference and exhibit
who	the american society of mechanical engineers
where	shoreham hotel, washington, d. c.
when	march 2-6

what	nuclear congress
who	coord. by engineers joint council
where	intern. amphitheater, chicago, ill.
when	march 16-22

◆

what	aviation division conference
who	american society of mechanical engineers
where	statler-hilton hotel, dallas, tex.
when	march 17-20

◆

what	national convention
who	institute of radio engineers
where	waldorf-astoria hotel and coliseum, new york, n. y.
when	march 24-27

◆

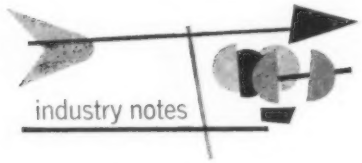
what	fifteenth annual pacific coast section conference
who	the society of the plastics industry, inc.
where	el mirador hotel, palm springs, calif.
when	march 26-28

◆

what	aeronautic meeting, aeronautic prod. forum and aircraft engineering display
who	society of automotive engineers
where	hotel commodore, n. y., n. y.
when	april 8-11

◆

what	second annual technical meeting
who	institute of environmental engineers
where	new yorker hotel, new york, n. y.
when	april 17-18



nored in the "near-hypnotic regard" for the missile, he said, is the fact that at least two more generations of manned aircraft will be built. The next generation of bombers, the AIA president predicted, will aim for speeds of Mach 3 and altitudes on the order of 75,000 feet. Fighter performances will be even greater.

No Rivalry Here

Sidewinder, the infrared homing air-to-air missile shown mounted on a Navy aircraft, is being ordered by the Air Force for use on F-104, F-100, and F-89 fighters.

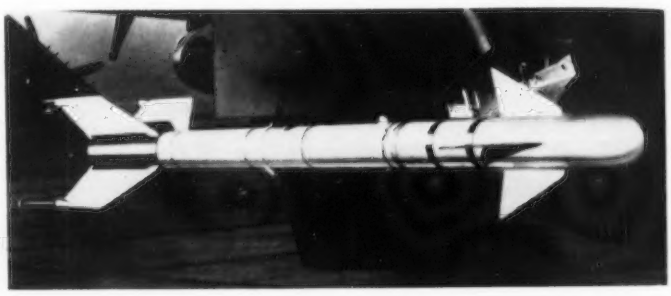
Sidewinder was developed by the Navy and was so successful as an operational weapon that the Air Force added it to its arsenal. This is typical of the quiet cooperation by the services in sharing proven weapons.

Talos, another Navy developed missile, is being used jointly by the Army and Navy as an operational weapon.

Sidewinder is produced by Philco Corp. and General Electric Co.

index to advertisers

	Page
Apex Machine & Tool Co.	83
Behlman Engineering Co.	Back Cover
Electro Tec Corp.	64
Hunter Mfg. Co.	82
Invo Spline, Inc.	3
King Fifth Wheel Co.	Inside Back Cover
Sciaky Bros., Inc.	1
Sealol Corp.	79
Sharon Steel Corp.	Inside Front Cover
Slip Ring Co. of America	82
Stackpole Carbon Co.	72
Titan Tool Co.	3



NO NEROS

So long as there is the problem of supporting or containing tubular shapes, formed and welded rings will be important components. For all we've read, seen and heard about ballistics missiles, they and their engines are—and for the foreseeable future, will be—tubular shapes. It follows that there will be an increasing demand for the kind of rings King forms and welds at Mountaintop.

Missiles men have not been fiddling while Sputniks soar. The armed services have done a commendable job considering the lack of cohesive leadership. We hope sincerely that, under the new program, our ballistics missiles can and will get off the ground to perform their appointed tasks.

We forecast that with more efficient propellants; with lighter, stronger, more heat resistant materials; but chiefly with new IDEAS—which may have little or no resemblance to conventional thinking—we have a better than even chance to move into a more favorable position in the missiles marathon.

King is of such fortunate size that it welcomes pilot orders, research commissions, small but important quantities of rings for aircraft and missiles engines. When they grow into production runs, King can handle them, too.

Consistently
better than
97.3%
Quality Level
Percentage

King

FIFTH WHEEL CO.
BOX 759 • WILKES-BARRE, PA.
Phone: GRanite 4-6371

Circle 83 on Inquiry Card, page 65

MODEL
253-D-3

NSTRUMENTATION YOUR CONCERN?

IF SO...

THE BEHLMAN INVERTRON®

The Behlman Invertron is a completely electronic A.C. Power Source widely used in research and development, production testing, test consoles or wherever A.C. Power other than that obtainable from 60 cycle line is required. A variety of models cover the range from milliwatts to kilowatts, from subsonic to supersonic frequencies and for single or multiphase output. Frequencies may be variable or fixed. The Invertron features frequency accuracy and stability, exceptional regulation and low distortion and noise.

For further information write or call

BEHLMAN ENGINEERING COMPANY

ELECTRONICS • MECHANICS • OPTICS
DESIGN • DEVELOPMENT • PROTOTYPE

2911 WINONA AVENUE
BURBANK, CALIFORNIA

Representatives in all principal cities and Canada

Visit our Display at the . . .

RADIO ENGINEERING SHOW
New York Coliseum, New York
March 24-27, 1958
Booth No. 3926

Circle 84 on Inquiry Card, page 65